ELECTRONICS & Wireless world

OCTOBER 1983 85p

10-21-83 #3.75

Nanocomp/tty interface

Forth language

Digital rate meter

Precision preamplifier

Electronic weighing scale

www.americanradiohistory.com

The over and outperformer

SHURE

You simply can't make it any clearer.

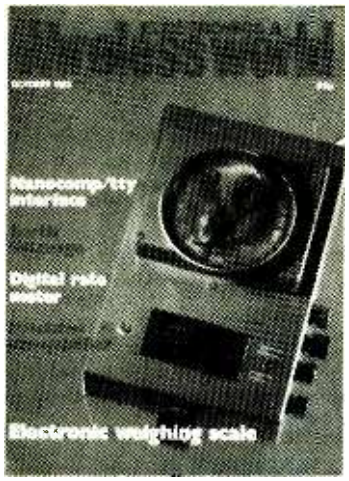
For the address of your nearest dealer together with full details of the Shure Microphone range, write to:
HW international Dept. WW. 3-5 Eden Grove, London N7 8EQ or telephone: 01-607 2717.

WW – 027 FOR FURTHER DETAILS

www.americanradiohistory.com

FOR EVERYTHING IN ELECTRONICS
Wireless world

OCTOBER 1983 VOL 89 NO 1573



Front cover is John Linsley Hood's strain-gauge weighing scale, photographed by Alan McFaden.

NEXT MONTH

Battery charger. A Wireless World design for recharging up to 15 NiCd cells in series. It has automatic shutdown and uses a switch mode source.

Careers. Where you should train, where you should go for a job and how much you can expect to be paid – all investigated by an experienced job-finder.

Tone-burst gate. Provides burst or square-wave output with variable duty cycle of 1-9999 to 9999-1.

Video disc information retrieval. Using a computer and disc player in an interactive information storage system.

Current issue price 80p, back issues (if available) £1, at Retail and Trade Counter, Units 1 & 2, Bankside Industrial Centre, Hopton Street, London SE1. Available on microfilm; please contact editor.
By post, current issue £1.23, back issues (if available) £1.80, order and payments to EEP General Sales Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS Tel: 01-661 8668.
Editorial & Advertising offices: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
Telephones: Editorial 01-661 3614. Advertising 01-661 3130. See leader page.
Telex: 892084 BISPRS G.
Subscription rates: 1 year £15 UK and £17 outside UK.
Student rates: 1 year £9.35 UK and £11.70 outside UK.
Distribution: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Telephone 01-661 3248.
Subscriptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone: 0444 459188. Please notify a change of address.
USA: $44 surface mail, $93.80 airmail. Business Press International (USA). Subscriptions Office, 205 E.42nd Street, NY 10017.
USA mailing agents: Expediters of the Printed Word Ltd, 527 Madison Avenue, Suite 1217, New York, NY 10022. 2nd class postage paid at New York.
© Business Press International Ltd 1983
ISSN 0043 6062.

23 **THE PERSUADERS**

24 **COMMUNICATIONS COMMENTARY**

26 **STRAIN-GAUGE WEIGHING SCALE**
by J. L. Linsley Hood

31 **PRECISION PREAMPLIFIER**
by D. Self

35 **CURRENT DUMPING REVIEW**
by M. McLoughlin

42 **RAPID-UPDATE DIGITAL RATEMETER**
by P. D. Coleridge-Smith

45 **MICROCOMPUTER ANALYSIS OF LADDER NETWORKS**
by L. E. Weaver

51 **NEWS OF THE MONTH**
Occam programming Satellite news Light-fibre multiplexer

54 **WORLD TIMING ASSESSMENT USING H.F. BROADCASTS**
by R. C. Macario and G. R. Munro

57 **CIRCUIT IDEAS**
Dot matrix display 6-digit counter Current sensor

60 **IMPROVING STEREO AT L.F.**
by Y. Hirata

63 **PROBLEMS IN SPECIAL RELATIVITY**
by I. McCausland

66 **USING A MICRO TO PROCESS 30-LINE BAIRD TV RECORDINGS**
by D. F. McLean

71 **ASSEMBLY-LANGUAGE PROGRAMMING**
by R. F. Coates

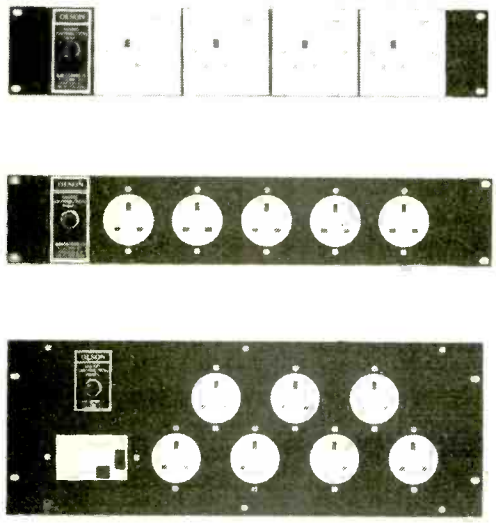
73 **FORTH COMPUTER**
by B. Woodroffe

75 **NANOCOMP TO TTY INTERFACE**
by P. C. Barton

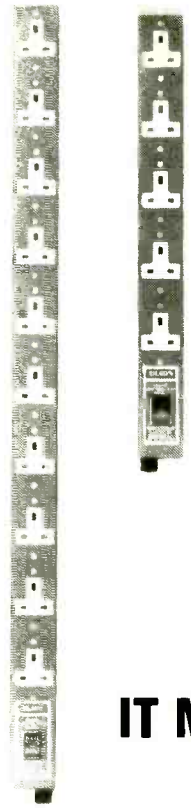
77 **LETTERS TO THE EDITOR**

81 **NEW PRODUCTS**

www.americanradiohistory.com



VERTICAL



OLSON

HORIZONTAL OR

VERTICAL RANGE FROM 3-10 SOCKETS
ALL EX-STOCK!
SPECIALS TO ORDER

WHEN
IT COMES
TO POWER
FOR RACKS
IT MUST BE OLSON

OLSON ELECTRONICS LIMITED

5-7 LONG STREET LONDON E2 8HJ
TEL: 01-739 2343 TELEX 296797

WW – 032 FOR FURTHER DETAILS

Out of this world for value!

ET Not our extra-terrestrial friend, but a versatile bench power supply –

– the ET30/2

For a modest price it will provide you with:

2 outputs at 0 to 30 volts d.c. at 1 amp or
2 outputs at 0 to 15 volts d.c. at 2 amps or
0 to 30 volts d.c. at 2 amps or 0 to 60 volts
d.c. at 1 amp or 0 to 15 volts d.c. at 4 amps.

from Farnell

Send for details now from: FARNELL INSTRUMENTS LIMITED · WETHERBY · WEST YORKSHIRE LS22 4DH
TELEPHONE (0937) 61961 · TELEX 557294 FARIST G | REGIONAL OFFICE TELEPHONE (05827) 66123/4 · TELEX 826307

WW – 030 FOR FURTHER DETAILS

www.americanradiohistory.com

ELECTROVALUE

THE WW ENTHUSIAST'S A-Z BUYING GUIDE

It's amazing what you'll find in the pages of our current price list, be you beginner, expert or professional. The list below gives some indication of the enormous stocks we carry and our service is just about as good as meticulous care can make it. WRITE, PHONE OR CALL FOR OUR LATEST PRICE LIST NOW!

IT'S FREE!

Please mention this journal when replying

Good Bargains
Good Choice
Good Service

Access facilities	Connectors	Lamps	Semi-conductors
Aerosols	Discounts	Meters	Solder tools
Batteries	Electrolytics	Opto-electronics	Switches
Boxes	Ferrites	Pot cores	Tools
Breadboards	Grommets	Potentiometers	Transformers
Capacitors	Hardware	Quantity prices	Vero products
Computers and Equipment	I.Cs.	Relays	Visa facilities
	Knobs	Resistors	Zener diodes

ELECTROVALUE LTD. 28 St. Jude's Road, Englefield Green, Egham, Surrey, TW20 0HB. Egham 33603 (London 87: STD 0784). Telex 264475. ***Northern Shop*** **(callers only), 680 Burnage Lane, Manchester (061-432 4945).** ***EV Computing Shop,*** **700 Burnage Lane, Manchester (061-431 4866).**

---

pantechnic

THE POWERFET SPECIALISTS

OEM USERS

Pantechnic present the most adaptable high-powered amplifier ever.

FET SYSTEM AMP

Features:
- HIGH POWER. 1.2kW (single ended)
- LOW VOLUME. 1/15 Cubic foot inc. Heatsink
- VERSATILE. Delivers more than 1kW into ½ to 8 ohms

OR 2 × 600W into 2 to 8Ω
OR 4 × 300W into 2 to 4Ω (200W into 8Ω)
OR { 1 × 600W into 2 to 8Ω; 1 × 300W into 2 to 4Ω; 1 × 150W into 4 to 8Ω }
Etc., etc.

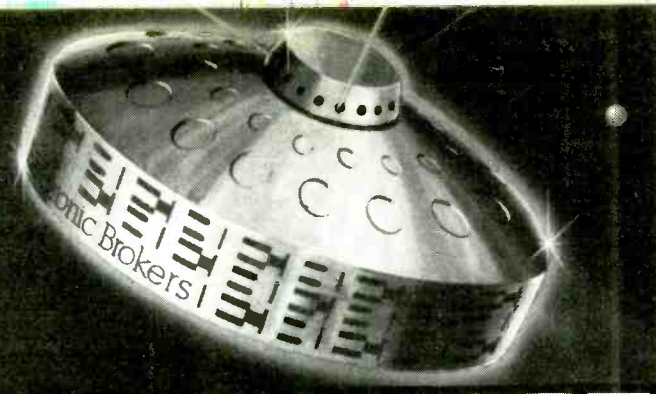
Having been closely involved in a wide variety of OEM applications of their amp boards. Pantechnic became aware of numerous implementation problems often left untackled by other amp board manufacturers. These problems specifically of size and thermal efficiency became particularly aggravated at high powers and considerably lengthened OEM product development time.
By including thermal design in the totality of board design it has been possible to reduce the size of the electronics, and increase the efficiency of the transistor to heatsink thermal circuit. The combined effect of this has been to dramatically increase the volumetric efficiency of the amplifier/heatsink assembly. The **SYSTEM** Amp offers 1.2kW of power in a space of 180mm x 102mm × 77mm, excluding PSU and Fan.
The basis of this considerable advance is the PANTECH 74 Heat Exchanger, newly designed and manufactured by us. By eliminating the laminar air flow found in conventional, extruded heatsinks, heat transfer to the environment is greatly enhanced.
The flexibility of the 1.2kW amp stems from its division into 4 potentially separate amplifiers of 300W each (downrateable with cost savings to 150W). These can be paralleled, increasing current capability or seriesed (bridge in pairs) doubling voltage capability. In consequence a large variety of amplifier/load strategies can be implemented
As ever Pantechnic offer a full range of customising options including DC coupling, ultra-high slew, etc. Contact Phil Rimmer on 01-800 6667 with your particular application problem.
P.S. Specs, as ever, are exemplary.

A wide range of other amplifiers and other modules available.

Price and Delivery
PANTECHNIC (Dept. WW10)
17A WOOLTON STREET
LIVERPOOL L25 5NH
Tel: 051-428 8485

Technical Enquiries contact Phil Rimmer on 01-800 6667

WW – 036 FOR FURTHER DETAILS



THE SOURCE OF ALL GOOD USED TEST EQUIPMENT

ANALYSERS

Hewlett Packard
1615A/001 Logic Analyser £4750.00
5004A Signature Analyser £550.00
8407A/8412A Network Analyser £1800.00

Marconi
TF2303 Mod Meter £460.00

Tektronix
AA501 opt 01. Distortion 10Hz — 100KHz to Less than 0.0025% £1450.00
DAS 9103 opt 01 02. Logic Analyser £11,000.00
DF1 Display Formatter For 7D01 ..... £850.00
308 Portable 8 Channel 20MHz Data Analyser £2100.00
491 Spectrum Analyser 10MHz-40GHz £7500.00
492 (opt 01, 08) Spectrum Analyser 50KHz-21GHz £13000.00
492P (opt 01, 2, 3) Programmable Version of 492 ..... £20000.00
7L5 Spectrum Analyser with opt 25 (Tracking Gen) and L3 (50Ω input) 20Hz — 5MHz £7300.00
7L12 Spectrum Analyser 100KHz-1.8GHz £6000.00
7L13 Spectrum Analyser 1KHz-1.8GHz £7500.00
7L14 Spectrum Analyser 10KHz-1.8GHz £9450.00
7L18 Spectrum Analyser 1.5GHz-60GHz £7500.00
TR502 Tracking Generator (for 7L12, 13 & 14) £3200.00
TR503 Tracking Generator (for 492/496 series) £3250.00
5L4N Spectrum Analyser 20Hz-100KHz £2350.00
7D01 16 Channel 100MHz Sample Rate £2450.00
7D02/01 Logic Analyser £3850.00

DMM's

Fluke
8020A 3½ digit 0.1% Basic DC Accuracy
7 functions £75.00
THESE DMM'S ARE UNUSED
90 DAY WARRANTY

OSCILLOSCOPES

Hewlett Packard
1332A High Quality CRT Display 9.6 x 11.9cm. £1250.00
1809A 100MHz 4 Channel Plug In £2000.00
1821A Timebase Plug In £1000.00

Philips
PM3232 Dual Beam 10MHz £495.00

Tektronix.
305 Portable battery scope/DMM, D T 5MHz £875.00
335 Dual Trace 35MHz Smal portable with delay T Base £1300.00
200C Trolley for 400 Series £120.00
7313 100MHz Storage Mainframe £2225.00
7603 100MHz Mainframe £1850.00
5440 50MHz Mainframe £1000.00
5441 50MHz Variable Persistance Storage Mainframe £1600.00
7704A Scope DC-200MHz Mainframe £2500.00
7613 Storage Scope Mainframe DC-100MHz £3250.00
7834 Storage Scope Mainframe DC-400MHz £7200.00
7844 Dual Beam 400MHz Mainframe £7750.00
7854 Waveform Processing Scope DC-400MHz £9000.00
7904 opt 02, 03 500MHz £5350.00

TEKTRONIX PLUG INS

We stock a complete range of Plug Ins for use with 7000 and 5000 series Mainframes.

TEKTRONIX TM500 SERIES

We stock a very wide range of these versatile modular equipments

TEKTRONIX TV TEST EQUIPMENT

148 Sig Gen £4000.00
141A Sig Gen £1500.00
1485R Waveform Monitor £3200.00
651HR PAL Monitor £2100.00
655HR-1 Monitor £3800.00
656HR PAL/SECAM Monitor £3900.00
671 PAL Monitor £1800.00

MISCELLANEOUS

Avo
VCM 163 Value Characteristic Meter £495.00
7 Electricians Multimeter £65.00

Bruel & Kjaer
2209 Sound Level Meter £850.00

Datalabs
DL901 Transient Recorder £750.00
DL905 Transient Recorder £995.00

Fluke
515A Portable Calibrator £1750.00
845 AB Null Detector £610.00
931B Diff V'Meter £1,000.00
1900A Counter/Timer 80MHz £225.00
2020A -3-6 Printer £500.00
3010A Logictester. Self Contained. Portable. Full Spec. on Request £8500.00
8921A DMM £695.00

Hewlett Packard.
3200B Oscillator £850.00
467A Amplifier £725.00
415E VSWR Meter £950.00
214A Pulse Gen £950.00
3556A Psophometer £850.00
435A Power Meter £850.00
3552A Trans Test Set £1,500.00
5300B/5306A DMM/Counter £1,200.00
8013B Pulse Generator £750.00
8350A/83525A Sweeper System £9,500.00
4815A Vector Impedance Meter £3850.00
11720A Pulse Modulator £1950.00

Marconi
TF1313A LCR Bridge £775.00
TF2120 Waveform Gen £850.00
TF2603 RF Millivolt meter £750.00
TF2000 Oscillator £575.00
TF2015/2 + TF2171 AM/FM Sig Gen £1950.00

Racal
9514 Counter/Timer IEEE £850.00
9917A/04A Counter 560MHz £450.00

Tektronix
106 Square Wave Generator 1nS risetime 10Hz-1MHz without accessories £175.00
191 Constant Amplitude Generator £250.00
832 Data Comms Tester £925.00
833 Data Comms Tester £1350.00
2701 Step Attenuator 50Ω 0.79dB in 1dB steps. DC to 2GHz £295.00
2901 Time-Mark Generator £195.00

STOP PRESS
New Catalogue Just Out
Send for your free copy now

Please note: Prices shown do not include VAT or carriage.

Electronic Brokers Ltd., 61/65 Kings Cross Road, London WC1X 9LN. Tel: 01-278 3461. Telex 298694

Electronic Brokers

WW – 202 FOR FURTHER DETAILS

www.americanradiohistory.com

REGD. TRADE MARK

TEONEX

TEONEX ELECTRONIC VALVES AND SEMICONDUCTORS

SERVING THE WORLD FOR 30 YEARS

We specialise in the supply of
Industrial Valves of British, European and USA manufacture,
and semiconductors from the Philips Group.
Many types, including obsolete and obsolescent types,
always available from stock.

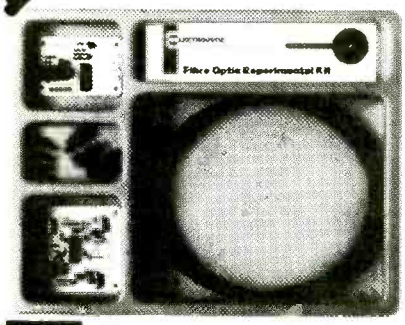
For further details, contact Mrs. Janet Lowy.

T.O. SUPPLIES (EXPORT) LTD., 2A Westbourne Grove Mews, London W11 2RY.
Telephone: (01) 727 3421 Telex: 262256 Answerback TOSPLY G

WW – 008 FOR FURTHER DETAILS

NEW

Get started in Fibre Optics



. . . with our new fibre optic experimental kit.

Features include:

- 0-10Mbit/s (NRZ) guaranteed to 15m with Polymer Cable. (Can be extended by using a glass fibre).
- TTL Compatible.
- No tools required to terminate cable.
- Fully tested modules.
- Complete with transmitter, receiver connectors and 5m of Polymer Cable.
- Also a full range of components for glass systems available.

Electroustic Ltd.
Hayward House, Northchapel, West Sussex, GU28 9HL.
Tel: (042 878) 611/2. Telex: 858966.

WW – 021 FOR FURTHER DETAILS

RADFORD

Audio Measuring Instruments, Audio Amplifiers, Loudspeakers and Loudspeaker Components for the professional and enthusiast

RADFORD AUDIO LTD.

10 BEACH ROAD
WESTON-S-MARE, AVON BS23 2AU
TEL. 0934 416033

WW – 005 FOR FURTHER DETAILS

SALE* SALE*

P.&R. COMPUTER SHOP

IBM GOLFBALL PRINTERS from £70 EACH + V.A.T.

INTERFACE FOR IBM GOLFBALL £40 + V.A.T.
*BRAND-NEW LA36 DEC WRITERS – SALE £200 EACH + V.A.T.
CENTRONIC 779 PRINTERS – £325 + V.A.T.
CENTRONIC 781 PRINTER – £350 + V.A.T.
POWER UNITS, 5-VOLT 6-AMP – £20 EACH
FANS, PCBs, KEYBOARDS AND LOTS MORE
8-INCH IBM FLOPPY DISC DRIVES.

COME AND LOOK AROUND

SALCOTT MILL, GOLDHANGER ROAD
HEYBRIDGE, MALDON, ESSEX
PHONE MALDON (0621) 57440

WW – 057 FOR FURTHER DETAILS

www.americanradiohistory.com

TEST EQUIPMENT

	£
10cm Variable Airlines	25
20cm Variable Airlines	35
Electrohome 19" B&W X-Y Monitors – NEW (details available)	25
Philips PM3244 4-Channel 50MHz Sweep Delay Scope	895
Tek. 465B 100MHz Scope with DM44 Option – complete with all probes, temp. probe, manuals and pouch – as new	1800
Tek. Type 113 Delay Cable	50
Tek. 7L18 Spectrum Analyser Plug-in 1.5 to 60GHz – as new	7250
Tek. 2213 60MHz Scope – as new	725
Philips 2522A 4½ digit DMM	145
Fluke 8000A 3½ digit DMM	65
Fluke 8030A Battery/Mains 3½ digit DMM	65
Fluke 8600A 4½ digit DMM	155
Systron Donner 6250A 8-digit Timer Counter BCD output	135
Tek. 7B70 Plug-in	140
APLAB 25v Metered PSU	40
Racal 9076 4½ digit DVM	50
H.P. 7100B 2-pen chart recorder with 17500A and 17505A P.I.	395
Tek. 1A6 Plug-in	45
Tek. 3A6 Plug-in	35
Tek. 2A63 Plug-in	35
Avometer Model 7 Mk. 2	60
Leader LB0510 4MHz Single Channel Scopes – NEW	95
Marconi TF144H Signal Generator 20KHz to 72MHz	195
Marconi TF2410 8-digit 120MHz Counter with 100MHz Video Amp, 600MHz Converter and 3.4GHz Converter P.I. units	195
Tek. Type M4 Channel Plug-in	60
Tek. Type CA, Z, P Plug-ins	25
Tek. 564 10MHz Storage Scope with 3A3 & 2B67 Plug-ins	200
Tek. 564B 10MHz Storage Scope with 3A3 & 2B67 Plug-ins	225
Systron Donner 7344A DMM 4½ digit IEEE	260
Telequipment D43 Oscilloscope	65
Dynamco D7100 Oscilloscope	195
Telequipment D83 large screen 50MHz Delayed Sweep Scope	395
Rohde & Schwarz Inductance Meter Type LRT 0.1uH-1H	195
Tek. Type 184 Time Mark Generators	125
Tek. Type 191 Constant Amplitude Generators	115
Tek. Type 106 Fast Rise Pulse Generators	95
Tek. Standard Amplitude Calibrators Type 067-050-200	95
Singer Synchro Resolver Test Set	695
Hedin Furnace –20° to 150°	295
H.P. 184C 50MHz Storage Scope + 1825A & 1801A P.I.	795
Datapulse 114A Pulse Generator	95
Fluke 8050A Battery/Mains 4½ digit DVM	205
Flann 0-90dbs X Band Variable Attenuators – unused	175
Selectest Super 50 Multimeter	45
Houston DP10 Incremental Plotters	175
Tek. 661 Sampling Scope with 5T3 & 4S1 Plug-ins	185
Bendix Digitiser Complete with 3' x 4' Table	250
DRI Series 30 2.5 MegaByte Disk Drives	100
Full size Draughtsman Table – Neolt	125

Carriage additional. All prices exc. V.A.T.

TIMEBASE

94 ALFRISTON GARDENS, SHOLING, SOUTHAMPTON SO2 8FU
TELEPHONE: 431323 (0703)
Callers welcome
Access/Barclaycard: Telephone your order

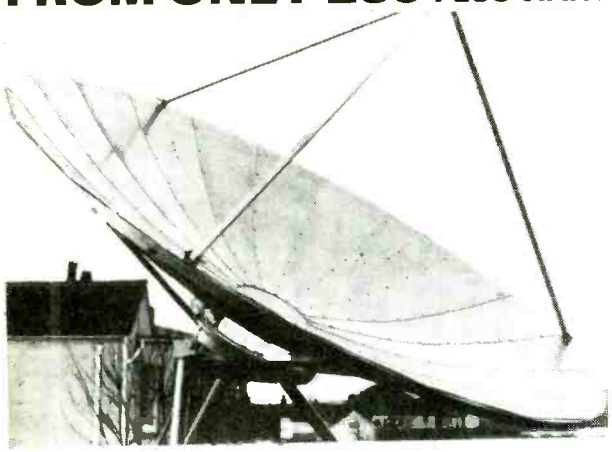
Buy it with Access — BARCLAYCARD VISA

WW – 060 FOR FURTHER DETAILS

HBED

6FT. PARABOLIC DISHES

FROM ONLY £85 PLUS V.A.T.



6ft. dia. dishes, feed horns and electronics for use in 4GHz satellite reception. GaAs Fet transistors, SMA connectors, P.T.F.E., etc. available.

Please send s.a.e. for full details and data sheets.

Harrison Bros.

Electronic Distributors

22 Milton Road, Westcliff-on-Sea, Essex SS0 7JX
Tel. Southend (0702) 332338

WW – 007 FOR FURTHER DETAILS

DEC SALE

a selection from our huge stocks. All items reconditioned unless otherwise stated.

NEW AUTUMN' 83 CATALOGUE now out
send for your free copy

SPECIAL PURCHASE OF PDP11/34A PROCESSORS

11/34A CPU
MS11JP 64KB MOS Memory
DL11W Console Interface
KY11LB Programmers Panel,
M9312 Bootstrap
BA11L 5 ¼" Chassis
ONLY £2,500

DEC LSI PROCESSORS

11/03LX KD11HA CPU, KEV11 EIS/FIS, BDV11AA Terminator/Bootstrap. BA11N 5¼ Chassis with Backplane and Power Supply. No memory included.
NEW £1200

11/03N KD11Q CPU, KEV11 EIS/FIS, BDV11AA Terminator/Bootstrap. BA11R 5¼" Chassis with Backplane and Power Supply, MSV11DD 32KW MOS
NEW £1495

DEC MAG TAPE

TE16 Slave	£4,500
TE16 Master with TM02	£5,750
TE16 Master with TM03	£6,250
TS11 Inc. Unibus Ctl NEW	£6,250
TU77 Master with TM03 NEW	£14,500

All above include DEC Cabinet

VT100—PLUS

SPECIAL PURCHASE
BRAND NEW SURPLUS

DEC PDT11/130 PROGRAMMABLE DATA TERMINAL COMPRISING:

* VT100 with Advanced Video Option
* Integral LSI Processor with 32K RAM
* Integral dual TU58 mini cartridge

Fantastic value whether for use as VT100 only or as full PDT

£995 including comprehensive manual

DEC DISK DRIVES

RK07ED 28MB	£2,500
RK07PD 28MB	£2,500
RL01A 5MB	£995
RM02AD 67MB NEW	£6,250
RM03AD 67MB NEW	£6,250
RM05AD 256MB NEW	£14,750
RM80 124MB	£9,500
RX11BD Dual Floppy	£995
RX211BD Dual Floppy	£1,725

DECSCOPE TERMINALS

VT50AB 20mA	£199
VT50-AF EIA	£225
VT52-AB 20mA	£350
VT52-AF EIA	£395
VT55-EB 20mA	£450
VT55-EF EIA	£495
VT55-FB + Copier, 20mA	£710
VT55-FF + Copier, EIA	£750

SCOOP PURCHASE OF TEKTRONIX GRAPHICS EQUIPMENT

EX-DEMONSTRATION STOCK IN ORIGINAL MANUFACTURER'S PACKAGING, HUGE SAVINGS ON NEW PRICES ONLY SLIGHTLY USED — COVERED BY FULL WARRANTY

HIGH RESOLUTION BIG SCREEN GRAPHICS DISPLAY TERMINALS

4014-1, 4015-1 and 4016-1

19in. Screen providing 4096X by 3120Y displayable points or 8512 alphanumerics (models 4014 and 4015). 25in. Screen providing 4096X by 3120Y displayable points or 15,000 alphanumerics (model 4016). APL Character Set (model 4015). Plot-10 compatible. Prices include Enhanced Graphics Option. Extra Memory Option and Programmable Keyboard Option.
4014-1 **£6,950.** 4015-1 **£7,250.** 4016-1 **£8,950.**

Other Tektronix graphics equipment currently available includes 4006-1, 4010-1, 4027, 4051, 4952, 606/606A/606B and 611.

ADD 15% VAT TO ALL PRICES Carriage and Packing extra

Electronic Brokers Ltd., 61/65 Kings Cross Road, London WC1X 9LN. Tel: 01-278 3461. Telex 298694

Electronic Brokers

WW – 203 FOR FURTHER DETAILS

www.americanradiohistory.com

LANGREX SUPPLIES LTD

Climax House, Fallsbrook Rd., Streatham, London SW16 6ED

RST **Tel: 01-677 2424 Telex: 946708** RST

SEMICONDUCTORS

AA119	0.10
AAY30	0.17
AAY30	0.17
AAZ13	0.15
AAZ15	0.15
AAZ17	0.15
AC107	0.55
AC125	0.25
AC126	0.25
AC127	0.25
AC128	0.30
AC141	0.28
AC141K	0.35
AC142	0.28
AC142K	0.35
AC176	0.30
AC187	0.28
AC188	0.28
ACY17	1.30
ACY18	1.15
ACY19	1.10
ACY20	1.10
ACY21	1.15
ACY39	2.50
AD149	0.75
AD161	0.3[illegible]
AD162	0.35
AF106	0.35
AF114	0.75
AF115	0.75
AF116	0.75
AF117	0.75
AF139	0.33
AF186	1.00
AF239	0.39
AFZ11	4.00
AFZ12	4.00
ASY26	1.40
ASY27	0.90

ASZ15	1.20
ASZ16	1.10
ASZ17	1.00
ASZ20	2.30
ASZ21	2.50
AU113	2.50
AUY10	3.00
BA145	0.13
BA148	0.15
BA154	0.10
BA155	0.11
BA156	0.10
BAW62	0.05
BAX13	0.06
BAX16	0.06
BC107	0.16
BC108	0.16
BC109	0.16
BC113	0.15
BC114	0.15
BC115	0.18
BC116	0.19
BC117	0.23
BC118	0.18
BC125	0.18
BC126	0.18
BC135	0.15
BC136	0.19
BC137	0.19
BC147	0.12
BC148	0.12
BC149	0.13
BC157	0.13
BC158	0.13
BC159	0.13
BC167	0.11
BC170	0.11
BC171	0.11
BC172	0.11

BC173	0.11
BC177	0.28
BC178	0.28
BC179	0.28
BC182	0.11
BC183	0.11
BC184	0.11
BC212	0.11
BC213	0.11
BC214	0.11
BC237	0.11
BC238	0.11
BC301	0.33
BC303	0.34
BC307	0.11
BC308	0.11
BC327	0.12
BC328	0.12
BC337	0.12
BC338	0.12
BCY30	1.25
BCY31	1.50
BCY32	1.50
BCY33	1.10
BCY34	1.00
BCY39	3.40
BCY40	2.80
BCY42	0.30
BCY43	0.30
BCY58	0.19
BCY70	0.17
BCY71	0.18
BCY72	0.17
BCZ11	1.75
BD115	0.42
BD121	1.70
BD123	2.80
BD124	2.00
BD131	0.44

BD132	0.48
BD135	0.40
BD136	0.40
BD137	0.40
BD138	0.48
BD139	0.48
BD140	0.50
BD144	2.00
BD181	1.20
BD183	0.80
BD2137	0.54
BD238	0.54
BDX10	0.91
BDX32	2.00
BDY20	1.50
BDY60	2.75
BF115	0.35
BF152	0.16
BF153	0.16
BF154	0.17
BF159	0.17
BF160	0.17
BF167	0.24
BF173	0.30
BF177	0.35
BF178	0.35
BF179	0.35
BF180	0.28
BF181	0.28
BF182	0.30
BF183	0.28
BF184	0.28
BF185	0.30
BF194	0.14
BF195	0.12
BF196	0.13
BF197	0.14
BF200	0.40
BF224	0.25
BF244	0.28

BF257	0.27
BF258	0.27
BF259	0.28
BF336	0.34
BF337	0.33
BF338	0.36
BFS21	4.00
BFS28	2.25
BFS61	0.20
BFS98	0.20
BFW10	0.97
BFW11	0.96
BFX84	0.30
BFX85	0.30
BFX87	0.30
BFX88	0.30
BFY50	0.25
BFY51	0.25
BFY52	0.25
BFY64	0.30
BFY90	0.95
BSX19	0.27
BSX20	0.27
BSX21	0.29
BT106	1.20
BTY79/400R	2.00
BU205	1.30
BU206	1.50
BU208	2.00
BY100	0.40
BY126	0.13
BY127	0.14
BZX61 Series	0.17
BZY88 Series	0.10
CRS1/40	0.60
CRS3/40	0.75
CRS3/60	0.90
GEX66	3.00

GEX541	5.00
GJ3M	1.50
GM0378A	1.75
KS100A	0.45
MJE340	0.60
MJE370	0.73
MJE371	0.71
MJE520	0.47
MJE521	0.73
MJE2955	1.30
MJE3055	1.10
MPF102	0.35
MPF103	0.35
MPF104	0.35
MPF105	0.35
MPSA06	0.26
MPSA56	0.28
MPSU01	0.53
MPSU06	0.65
MPSU56	0.69
NE555	0.45
NKT401	3.50
NKT403	2.50
NKT404	2.20
OA5	1.20
OA7	0.60
OA10	0.55
OA47	0.12
OA70	0.25
OA79	0.12
OA81	0.17
OA85	0.17
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.15
OA202	0.15
OA211	1.50
OAZ200	1.50
OAZ201	1.50
OAZ206	1.50

OAZ207	1.50
OC16	2.50
OC20	2.50
OC22	2.50
OC23	4.00
OC24	3.00
OC25	1.00
OC26	1.50
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.90
OC42	0.90
OC43	1.50
OC44	0.85
OC45	0.65
OC71	0.55
OC72	1.00
OC73	1.00
OC74	0.70
OC75	0.65
OC76	1.00
OC77	1.00
OC81	0.65
OC81Z	1.20
OC82	0.90
OC83	1.00
OC84	0.80
OC122	2.75
OC123	2.00
OC139	3.00
OC140	4.00
OC141	4.25
OC170	1.25
OC171	1.25
OC200	1.50
OC201	2.50
OC202	2.75
OC203	3.00
OC204	3.00

OC205	2.75
OC206	2.75
OC207	2.50
OCP71	2.00
ORP12	1.00
R2008B	2.00
R2009	2.25
R2010B	2.00
T1C44	0.27
T1C226D	1.20
T1L209	0.16
T1P29A	0.43
T1P30A	0.45
T1P31A	0.33
T1P32A	0.36
T1P33A	0.54
T1P34A	0.67
T1P41A	0.44
T1P42A	0.42
T1P2955	0.70
T1P3055	0.56
T1S43	0.43
ZS140	0.25
ZS170	0.21
ZS178	0.54
ZS271	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.18
ZTX303	0.18
ZTX304	0.20
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.18
ZTX503	0.19

ZTX504	0.21
ZTX531	0.24
ZTX550	0.25
1N914	0.05
1N916	0.09
1N4001	0.06
1N4002	0.06
1N4003	0.06
1N4004	0.07
1N4005	0.09
1N4006	0.11
1N4007	0.12
1N4009	0.07
1N4148	0.04
1N5400	0.13
1N5401	0.13
1S44	0.04
1S920	0.08
1S921	0.09
2G301	1.00
2G302	1.00
2G306	1.00
2N404	1.30
2N696	0.32
2N697	0.32
2N698	0.32
2N705	1.25
2N706	0.25
2N708	0.25
2N930	0.25
2N1131	0.30
2N1132	0.30
2N1302	1.20
2N1303	0.80
2N1304	1.20
2N1305	1.00
2N1306	1.50
2N1307	1.10
2N1308	1.75
2N1309	1.20
2N1613	0.32

2N1671	5.00
2N1893	0.32
2N2147	4.00
2N2148	3.75
2N2218	0.32
2N2219	0.32
2N2220	0.20
2N2221	0.20
2N2222	0.20
2N2223	4.25
2N2368	0.25
2N2369A	0.25
2N2484	0.25
2N2646	0.50
2N2904	0.32
2N2905	0.32
2N2906	0.21
2N2907	0.21
2N2924	0.26
2N2925	0.22
2N2926	0.15
2N3053	0.26
2N3054	0.55
2N3055	0.65
2N3440	0.70
2N3441	0.85
2N3442	1.25
2N3614	2.20
2N3702	0.11
2N3703	0.11
2N3704	0.11
2N3705	0.11
2N3706	0.11
2N3707	0.11
2N3708	0.10
2N3709	0.11
2N3710	0.10
2N3711	0.10
2N3771	1.40
2N3772	1.60
2N3773	1.80

2N3819	0.30
2N3820	0.39
2N3823	0.60
2N3866	1.00
2N3904	0.17
2N3905	0.17
2N3906	0.17
2N4058	0.20
2N4059	0.20
2N4060	0.16
2N4061	0.16
2N4062	0.16
2N4124	0.16
2N4126	0.16
2N4286	0.15
2N4288	0.18
2N4289	0.18
2N4400	0.11
2N4401	0.11
2N4402	0.11
2N5457	0.32
2N5458	0.32
2N5459	0.32
2S017	10.00
2S019	12.00
2S026	25.00
2S103	1.50
2S302	2.00
2S303	1.50
2S322	3.50
2S324	3.50
2S701	2.00
2S745A	0.95
2S746A	0.95

VALVES

A1834	9.00
A2087	13.50
A2134	17.50
A2293	16.00
A2426	18.75
A2521	22.50
A2900	22.50
A3343	45.00
AZ31	2.75
AZ41	2.60
BK448	114.90
BK484	155.35
BS90	58.00
BS452	60.00
BS810	60.00
BT5	58.95
BT17	151.00
BT19	44.05
BT29	349.15
BT69	354.80
BT95	129.00
CBL31	4.00
CL33	4.00
CY31	3.00
C1K	20.00
C3A	22.00
C3JA	22.00
DA41	25.00
DA42	18.70
DAF91	1.75
DAF96	1.75
DET22	35.00
DET24	49.00
DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
DLS10	14.00
DLS15	12.50
DLS16	12.50
DLS19	12.50
DM70	2.00
DM71	2.00
DM160	4.75
DY87	1.50
DY802	1.50
E55L	22.00
E80CC	8.81
E80CF	11.27
E80F	13.58
E80L	13.37
E81CC	8.00
E81L	12.57
E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88CC	8.00
E90CC	8.61
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10

E130L	18.50
E180CC	10.50
E180F	9.90
E182CC	13.25
E186F	11.50
E188CC	8.25
E280F	22.51
E283CC	12.00
E288CC	17.50
EA52	32.25
EA76	2.50
EABC80	1.25
EAC91	3.50
EAF42	2.50
EAF801	2.00
EB41	4.00
EB91	1.50
EBC33	2.50
EBC41	2.50
EBC81	1.50
EBC90	1.25
EBF80	1.50
EBF83	1.75
EBF89	1.50
EBL31	4.00
EC90	1.25
EC91	8.00
EC92	1.75
EC157	325.40
ECC33	4.50
ECC35	4.50
ECC40	4.50
ECC81	1.75
ECC82	1.75
ECC83	1.75
ECC84	1.75
ECC85	1.75
ECC86	2.50
ECC88	2.10
ECC89	2.00
ECC91	8.93
ECC189	2.10
ECC807	1.75
ECC808	3.50
ECF80	1.55
ECF82	1.50
ECF86	2.50
ECH35	3.00
ECH42	3.50
ECH81	3.00
ECH83	2.50
ECH84	2.50
ECL80	1.50
ECL81	1.75
ECL82	1.50
ECL83	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37A	5.00
EF39	2.75
EF40	5.00
EF41	3.50
EF42	4.50
EF50	2.50
EF54	5.00
EF55	3.50
EF80	1.75
EF83	4.00

EF85	1.75
EF86	1.75
EF89	2.50
EF91	2.95
EF92	6.37
EF93	1.50
EF94	2.50
EF95	5.99
EF98	2.00
EF183	2.00
EF184	2.00
EF804S	12.00
EF805S	9.80
EH90	1.75
EK90	1.50
EL32	2.50
EL33	4.00
EL34MU1	3.00
EL36	2.50
EL41	2.80
EL42	2.50
EL81	5.25
EL83	6.00
EL84	2.25
EL86	2.75
EL90	2.25
EL91	9.69
EL95	2.00
EL156	25.00
EL360	8.50
EL500/504	3.00
EL509	7.00
EL821	13.00
EL822	13.97
EM34	5.00
EM80	2.50
EM81	2.50
EM84	2.00
EM85	2.75
EM87	2.50
EN32	17.46
EN91	£7.05
EN92	6.96
EY51	2.75
EY81	2.50
EY83	2.50
EY84	9.24
EY86	1.75
EY88	1.75
EY500A	3.00
EY802	1.75
EZ35	1.75
EZ40	2.50
EZ41	2.50
EZ80	1.50
EZ81	1.50
EZ90	2.00
FW4-500	3.50
FW4-800	3.50
G1 371K	35.00
G551K	12.00
G180.2M	17.50
G240.2D	12.00
G400.1K	17.50
GN4	9.00
GN4A	9.00
GS16	16.00
GT1C	15.00
GU50	20.00

GU51	20.00
GXU1	15.35
GXU2	30.00
GXU3	25.00
GXU4	44.50
GXU50	20.00
GY501	3.00
GZ32	2.50
GZ33	4.75
GZ34	3.00
GZ37	4.75
KT61	5.00
KT66	8.00
KT88	15.00
KTW61	2.50
KTW62	2.50
KTW63	2.50
M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	8.58
M8091	10.43
M8096	6.80
M8097	8.10
M8098	6.15
M8099	8.00
M8100	9.52
M8136	10.23
M8137	10.23
M8140	6.00
M8141	6.50
M8142	8.75
M8144	7.50
M8149	6.50
M8161	9.35
M8162	10.40
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2901	60.00
MU14	2.50
MX119	55.00
MX123	72.00
MX145	56.70
MX151	17.25
MX152	131.25
MX161	152.25
MX163	20.25
MX164	25.52
MX166	147.00
MX168	48.00
N78	15.00
OA2	3.25
OA3	2.50
OA4	6.00
OB2	4.35
OB3	2.50
OC2	4.35
OC3	2.50
OD3	2.50
OZ4	3.50

PC86	2.50
PC88	2.50
PC95	1.75
PC97	1.75
PC900	1.75
PCC84	1.50
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCE82	2.00
PCF80	2.00
PCF82	1.50
PCF86	2.50
PCF87	2.00
PCF200	3.25
PCF201	3.25
PCF801	2.50
PCF802	2.50
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	2.00
PCL85	2.50
PCL86	2.50
PCL805/85	2.50
PD500	6.00
PE06-40N	30.00
PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504/5	2.50
PL508	2.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PY33	2.50
PY81	1.75
PY82	1.50
PY83	2.50
PY88	2.00
PY500A	4.00
PY800	1.50
PY801	1.50
QQV02-6	16.50
QQV03-10	14.00
QQV03-20A	48.38
QQV06-40A	48.38
QQV07-50	66.90
QQZ06-40A	62.20
QU37	12.50
QV03-12	6.80
QV04-7	3.50
QV08-100	136.85
QY3-65	54.26
QY3-125	60.40

QY4-250	73.15
QY4-400	76.80
QY5-500	175.00
QY5-3000A	335.00
QZ06-20	32.70
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-250	32.68
RG3-250A	32.68
RG3-1250	59.50
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
S11E12	65.00
S130	6.00
S130P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
TT15	35.00
TT21	23.00
TT22	23.00
TT100	60.00
TY2-125	60.00
TW4-400	71.40
TY4-500	98.35
TY5-500	175.00
TY6-800	188.00
TY6-5000A	375.00
TY6-5000B	395.00
TY6-5000W	325.00
TY7-6000A	374.00
TY7-6000W	303.60
TZ40	25.00
U18-20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	12.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.25
UBF89	1.50
UCC84	1.75
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	2.50
UCL82	1.75
UCL83	2.75
UF41	2.00
UF42	2.10
UF80	1.75

UF85	1.75
UF89	2.00
UL41	3.50
UL84	1.75
UM80	2.00
UY41	2.25
UY85	2.25
VLS631	15.00
XG1-2500	45.80
XG2-6400	141.90
XG5-500	26.60
XG2-6400	162.00
XR1-1600A	53.75
XR1-3200	81.97
XR1-3200A	
XR1-6400	102.00
YD1120	395.00
YD1240	351.00
Z759	25.00
ZM1000	8.00
ZM1001	8.00
ZM1020	9.00
ZM1021	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
1B63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2AS15	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	175.00
2J70A	383.00
2J70B	336.00
2K25	125.00
3-400Z	85.00
3-500Z	85.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.00
3B240M	17.50
3B241M	17.50
3C23	25.00
3C45	24.50
3CX100A5	47.00
3E29	45.00
3S4	2.00
3V4	1.75
465A	60.00
4-125A	60.00
4-250A	80.00
4-400A	87.00
4B32	20.00

4C35	78.00
4CX250B	40.00
4CX350A	73.00
4X150A	60.00
4X150D	56.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	1650.00
5R4GY	3.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	7.10
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.00
6AN5	4.75
6AN8A	3.50
6AQ5	2.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	85.00
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.50
6CD6GA	5.00
6CG7	2.50
6CH6	13.00
6CL6	3.75

6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	33.50
6H1	14.00
6H2N	2.75
6H3N	2.75
6H6	3.00
6J4	5.50
6J6	8.93
6J7	4.75
6K4N	2.50
6K6GT	2.75
6K7	3.00
6K8	3.00
6KD6	7.00
6L6G	3.00
6L6GA	2.25
6L6GC	3.00
6L6GT	3.00
6L7	2.50
6N2P	2.50
6N3P	2.50
6N7	3.00
6P25	4.00
6Q7	3.75
6R7	3.25
6SA7	3.00
6SC7	2.75
6SF7	2.50
6SH7	3.00
6SJ7	3.25
6SK7	3.50
6SK7GT	3.00
6SN7GT	3.00
6SQ7	3.40
6SR7	4.00
6SS7	2.75
6U5G	3.50
6U8A	2.25
6V6GT	2.25
6X4	2.00
6X5GT	1.75
7B7	2.50
7C5	4.00
7C6	2.50
7H7	4.00
7R7	4.25
7S7	3.50
7Y4	2.25
7Z4	2.00
11E3	55.00
12AH8	5.00
12AT6	1.50
12AT7	1.75
12AU6	2.50
12AU7	1.75
12AV6	2.50
12AV7	3.50
12AX7	1.75
12AY7A	4.00
12B4A	3.50

12BA6	2.50
12BE6	2.50
12BH7	1.50
12BY7	3.00
12E1	20.00
12E11TT	170.00
12E14	35.00
13E1	20.00
19H4	27.50
19H5	47.50
24B9	67.25
30C15	2.00
30C17	2.00
30C18	2.00
30F5	1.60
30FL1/2	1.38
30FL12	1.80
30FL14	2.00
30L1	1.50
30L15	2.00
30L17	2.00
30P4	2.50
30P19	2.50
30PL1	3.00
30PL14	1.80
30PL15	1.80
35W4	1.00
50C5	1.50
75B1	6.05
75C1	4.50
85A1	7.50
85A2	4.45
90AG	12.96
90AV	12.96
90C1	6.00
90CG	14.54
90CV	15.45
92AG	12.96
92AV	12.96
95A1	8.45
150B2	6.50
150B3	8.35
150C2	3.25
150C4	6.00
211	35.00
723AB	125.00
803	25.00
805	45.00
807	3.75
811A	18.33
812A	18.33
813	125.86
833A	193.16
866A	20.03
872A	20.00
922	6.00
931A	18.50
1624	4.00
1625	3.50
2050	7.00
4212E	300.00
4212H	300.00
5544	81.97
5545	102.00
5551A	114.90
5552A	155.35
5642	9.00
5654	3.00
5651	4.45

5670	4.50
5675	28.00
5687	6.00
5696	4.50
5718	7.50
5725	5.50
5726	11.37
5727	7.05
5749	2.50
5751	4.00
5763	4.50
5814A	4.00
5840	4.00
5842	12.00
5876A	31.50
5879	5.00
5886	15.00
5963	2.50
5965	3.50
6005	2.25
6021	4.50
6057	10.23
6058	12.34
6059	6.00
6061	6.00
6063	3.75
6064	8.58
6067	10

SMC HIRE DIVISION

ANNOUNCEMENT

THE FOLLOWING ITEMS ARE AVAILABLE FOR HIRE FROM STOCK AT REALISTIC PRICES. WHERE HOME OFFICE RADIO LICENCES ARE REQUIRED SMC MAKE ALL THE ARRANGEMENTS.

1. 2-WAY HAND PORTABLE RADIOS
2. BASE STATIONS FOR USE WITH ABOVE
3. 60-FOOT TRAILER-MOUNTED TOWER
4. 1.6KW PETROL GENERATOR

Apply for details to:

SMC

SOUTH MIDLANDS COMMUNICATIONS LTD.
SM HOUSE, OSBORNE ROAD, TOTTON
SOUTHAMPTON SO4 4DN, ENGLAND
TEL: 0703 867333
TELEX: 477351 SMCOMM G

WW – 053 FOR FURTHER DETAILS

9in. MONITOR in attractive case – non-standard input – and matching ASC11 coded QWERTY KEYBOARD with Numeric Keypad and 27 function keys. With info. THE PAIR £40. Monitor only £25.
12in. MONITOR cased – non-standard input – and matching ASC11 coded QWERTY KEYBOARD with Numeric Keypad and 24 function keys. With info. THE PAIR £35. Monitor only £20.
INSTRUMENT CASE, standard 19in. width × 16in. deep × 10in. high. £5 each.
FLOPPY DISK DRIVE 8in. by MEMOREX with control electronics. £75 each P&P £5.
HARD DISK DRIVES by DATA RECORDING. Series 30. Front load with info. £125 each.
TEKTRONIX STORAGE DISPLAY UNIT type 611. Screen size 8½in. × 6½in. £495.
AZTEC 20in. black and white monitor. Video in £50.
TV-style 20in. MONITOR. Video in £30.
CREED 75 TELEPRINTER. Very good condition. £25 each. Carriage £7

Item No.
286 TEKTRONIX OSCILLOSCOPE Type 647A. Dual Trace 100MHZ Delay Sweep £450
287 TEKTRONIX STORAGE OSCILLOSCOPE Type 549. Dual Trace 30MHZ Dual Time Base £400
288 TEKTRONIX OSCILLOSCOPE Type 547. Dual Trace 50MHZ. Dual Time Base £250
289 TELEQUIPMENT OSCILLOSCOPE Type S43. DC-15MHZ £50
290 TELEQUIPMENT OSCILLOSCOPE Type S54. DC-10MHZ Solid State £110
2 TEKTRONIX STORAGE OSCILLOSCOPE type 564B with 3A6 and 3B3 ..... £395
3 TEKTRONIX OSCILLOSCOPE type 545B with 1A2 Dual Trace 33MHZ Dual TB £160
4 SE LABS OSCILLOSCOPE type SM111 Dual Trace 20MHZ Solid State £225
5 COSSOR OSCILLOSCOPE type CDU110 Dual Trace 20MHZ Solid State £150
6 SOLARTRON OSCILLOSCOPE type CO1400 Dual Beam 15MHZ Delay Sweep £90
7 MINISTRY OSCILLOSCOPE type CT436 Dual Beam DC 6MHZ £60
9 B&K ELECTRONIC VOLTMETER type 2409 2HZ-200KHZ £50
12 B&K AUDIO FREQUENCY SPECTROMETER type 2109 ..... £125
18 MARCONI SIGNAL GENERATOR type TF144H/4 10KHZ-7MHZ £125
20 MARCONI FM/AM SIGNAL GENERATOR TF1066B/1. 10-470MHZ Int and Ext AM/FM Mod £250
21 MARCONI FM/AM SIGNAL GENERATOR TF995A/3S 1.5-220MHZ AM/FM Mod £150
23 MARCONI RF POWER METER TF1020A/1 50 ohm DC-250MHZ £75
24 MARCONI SIGNAL GENERATOR TF1060/2 450-1200MHZ Late style £150
26 MARCONI FM/AM SIGNAL GENERATOR TF995A/5 1.5-220MHZ. AM/FM Mod £225
27 MARCONI UNIVERSAL BRIDGE TF868B £120
28 MARCONI RF POWER METER TF1152 range. 50 ohm £50
29 MARCONI SIGNAL GENERATOR TF2002A/S AM/FM 10KHZ-72MHZ AM/FM Mod £475
30 MARCONI SIGNAL GENERATOR TF2002. As above. AM only £250
31 MARCONI POWER METER TF893A 20HZ-35KHZ £75
33 MARCONI CARRIER DEVIATION METER TF791D 4-1024MHZ £95
34 MARCONI SENSITIVE VALVE VOLTMETER TF2600. 10HZ-10MHZ 1mV-300 Volts £75
36 MARCONI DISTORTION FACTOR METER TF142F 100-8000HZ £65
37 MARCONI VHF SIGNAL GENERATOR TF1064B/5M 68-108-118-185/450-470MHZ £95
38 MARCONI AUTOMATIC DISTORTION METER TF2337 ..... £225
44 H.P. VHF SIGNAL GENERATOR type 608C 10-480MHZ £150
46 H.P. 431B POWER METER with head type 8478B 10MHZ-18GHZ £250
51 WAYNE KERR SOURCE & DETECTOR SR268 ..... £450
52 WAYNE KERR VHF ADMITTANCE BRIDGE type B801B £95
53 H.P. UHF SIGNAL GENERATOR type 612A 450-1230MHZ £175
61 AIRMEC MODULATION METER type 210. 3-300MHZ £125
68 ADVANCE FM/AM SIGNAL GENERATOR SG63A 7.5-230MHZ £75
72 ADVANCE SIGNAL GENERATOR type J1A 15HZ-50KHZ £35
87 JERROLD SWEEP GENERATOR SYSTEM Model SS-300-5B 0-300MHZ £350
111 BRADLEY OSCILLOSCOPE CALIBRATOR type 156 ..... £175
113 RADIOMETER type AFM1 MODULATION METER 3.5-320MHZ £150
62 AIRMEC WAVE ANALYSER type 248 5-300MHZ £75
65 AIRMEC SIGNAL GENERATOR type 365 AM/FM 1-302MHZ £130
84 R&S SWEEP SIGNAL GENERATOR SWH BN4242/4 50KHZ-12MHZ £95
85 R&S NOISE GENERATOR SKTU BN4151/2/75. 1-1000MHZ £50
88 FLUKE DIFFERENTIAL VOLTMETER Model 821A £50
110 KAY SWEEP AND MARKER GENERATOR Type 1500C 20HZ-200KHZ £125
90 FLANN SIGNAL GENERATOR Type 501. P.S. 0.575-3GHZ £175
105 TELONIC SWEEP GENERATOR Type SD3M, 440-920MHZ with fixed markers £50

EXECUTIVE TELEPHONES PUSH BUTTON
Many functions including 10 number memory, repeat dialling, etc. Will connect to GPO System. Brand New. £25 each. P&P £4

EQUIPMENT IN WORKING ORDER
Please check availability before ordering. Carriage all units. £7. VAT to be added to total of Goods and Carriage. S.A.E. for LISTS

Stockists of NEW SAFGAN OSCILLOSCOPES. Also many other ITEMS OF TEST EQUIPMENT AND COMPONENTS in stock. For further details contact DWAYNE STEWART

STEWART OF READING

110 WYKEHAM ROAD, READING, BERKS R66 1PL
Telephone: 0734 68041

BARCLAYCARD VISA

Callers welcome 9 a.m. to 5.30 p.m. Monday to Saturday inclusive

WW – 052 FOR FURTHER DETAILS

Electronic Brokers

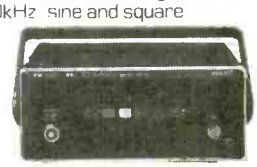
Test Equipment DISTRIBUTORS

PHILIPS

◄ Philips PM 2517X Handheld DMM £172
Multi-function, 4 digit autoranging with manual override. True RMS to 10Amp. Battery operation. Optional accessories extend measurement capabilities.

Philips PM 3207 15MHz Oscilloscope £385 ►
Tough light-weight portable for field service work with big screen. Dual trace, TV triggering, X-Y operation, add and invert.

◄ Philips PM 5107 Function Generator £295
Designed for audio and educational applications. Low distortion LF generator 10Hz to 100kHz sine and square waveforms. TTL output.

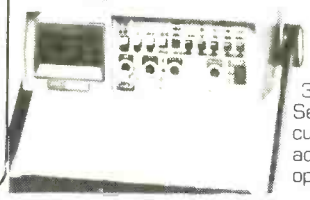


Philips PM 5501 Pattern Generator £296 ►
Compact unit for TV servicing and installation. Five different test patterns for colour and monochrome. Tone for audio checking. RF switchable.

◄ Philips PM 6667/01 Frequency Counter £290 High resolution 7 digit computing counter from 10Hz to 120MHz. Auto ranging on all waveforms. PM 6668/01 (£425) performs to 1GHz.

FLUKE

Fluke 8022B Handheld DMM £99 ►
Rugged 3½ digit, general purpose meter. Six functions include diode test. Extensive overload protection and two year warranty period.

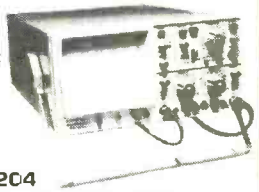


◄ 8010A Bench/portable DMM £210
Exceptional performance 3½ digit, true RMS meter. Seven functions with 10Amp current capability. Comprehensive accessories and Ni/Cd battery option available.

Fluke 8026B Handheld DMM £180 ►
Versatile 3½ digit, with true RMS capability. Eight functions include conductance and high speed audible continuity. Two year warranty applies.

HAMEG

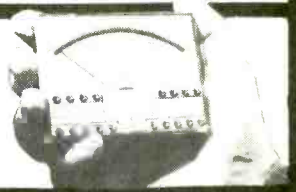
◄ Hameg HM 103 10MHz Oscilloscope £158 Single trace, suitable for field service or home constructor. Two year warranty applies to this and all Hameg instruments.



Hameg HM ► 203-4 20MHz Oscilloscope £264
Dual trace for general purpose applications in industry and education. X-Y operation, TV triggering, add/invert and component tester.

◄ Hameg HM 204 20MHz Oscilloscope £365 High performance instrument with sweep delay. Versatile triggering to 50MHz, variable hold off control, Z modulation and internal illuminated graticule.

ICE



I.C.E. Microtest 80 Multimeter £19
Compact meter in robust case. 40 ranges of measurement with high sensitivity and accuracy. Large range of inexpensive accessories.

ADD 15% VAT TO ALL PRICES Carriage and Packing extra

Electronic Brokers Ltd., 61/65 Kings Cross Road, London WC1X 9LN. Tel: 01-8331166. Telex 298694

Electronic Brokers

WW — 601 FOR FURTHER DETAILS

www.americanradiohistory.com

CX80 COLOUR MATRIX PRINTER

New low price
£795 + V.A.T.

At last a low-cost Colour Matrix Printer for Text, Graphics, Histograms, Colour VDU Dumps, etc.

Colour printout is quickly assimilated, makes graphics more understandable and is an ideal medium for the presentation of complex data or concepts.

Compatible with most microprocessors, prints in 7 colours – sophisticated internal programme makes the CX80 easy to use.

Dot Addressable + 15 user programmable characters, 96 ASCII and 64 graphics characters in rom. Centronics interface with RS232 and IEEE488 options. Apple II interface gives dot for dot colour dump. New viewdata interface prints out two pages side by side in full colour. See Prestel 200650.

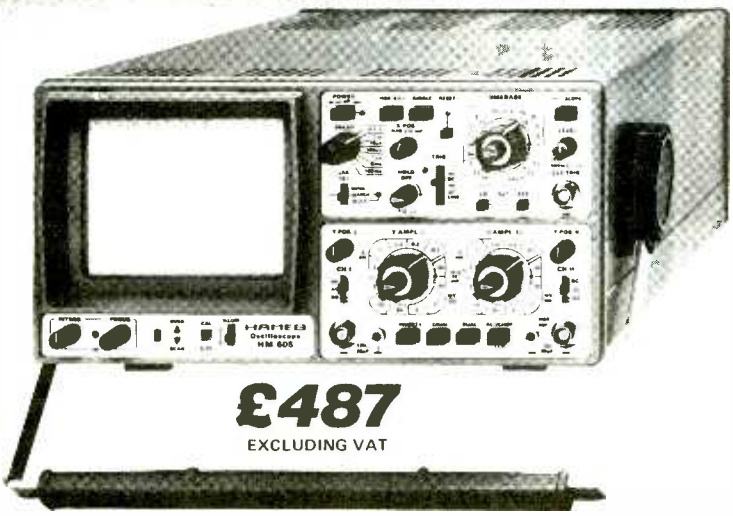
The CX80 is a product of our own design and development laboratories. It represents a British breakthrough in colour printer technology. Colour brochure on request. OEM pricing available.

INTEGREX LIMITED

Portwood Industrial Estate, Church Gresley
Burton-on-Trent, Staffs DE11 9PT
Burton-on-Trent (0283) 215432. Telex: 377106

HM 605 - The new 60 MHz-Performer

High quality scope at low cost



£487
EXCLUDING VAT

- 60 MHz Bandwidth
- 5mV-20V Sensitivity at 60MHz
- 1mV Sensitivity at 30MHz
- Timebase Range 5ns-2,5s/cm
- Reliable Triggering to 80MHz
- Normal and Peak Value Triggering
- Alternate Triggering
- Variable Sweep Delay
- 14kV Rectangular CRT
- Y-Output
- 1kHz/1MHz Calibrator
- HM8000-Compatibility
- 2 Years Warranty

Hameg Modular Test System HM 8000

write or call:

HAMEG LTD

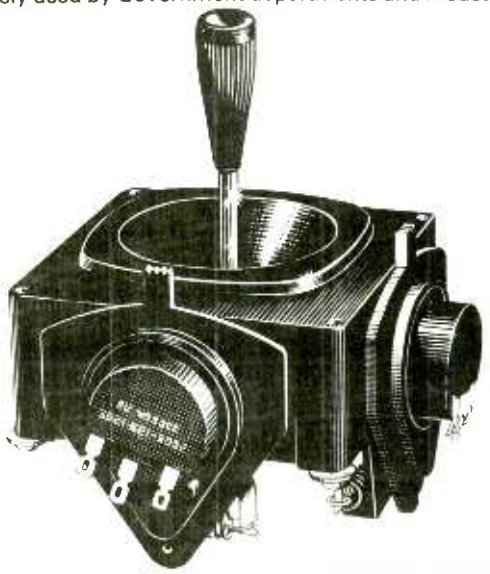
74-78 Collingdon St. • LUTON, Beds. LU1 1RX • ☎ (0582) 41.31.74 • Telex 825 484

WW – 066 FOR FURTHER DETAILS

www.americanradiohistory.com

PRECISION DUAL AXIS CONTROL STICK

Suitable for use with Computers, Robotics, Machine Tools
Widely used by Government departments and industry



SUPER SMOOTH PRECISE ACTION · SEPARATE FINE TRIM ADJUSTMENT · ACCURATE CENTRING LONG-LIFE MOULDED NYLON PARTS

Available in kit form – easily assembled. Standard version – Carbon track pots. 1 off £8.50, P&P 75p. De luxe version – Conductive plastic film pots. 1 off £12.80, P&P 75p. Send SAE for full details of sticks and servos suitable for Robotics. OEM and trade enquiries invited, Barclaycard and Access accepted.

SKYLEADER, DEPT 10, AIRPORT HOUSE, PURLEY WAY CROYDON, SURREY CR0 0XZ. 01-686 6688

WW – 049 FOR FURTHER DETAILS

ELECTRON GUNS TV TUBE COMPONENTS

If you are Rebuilding or Manufacturing TV Tubes – We are the leading suppliers of Electron Guns and TV Tube Components to the TV Tube Industry. We specialise in all aspects of Electron Mount Technology.

Our product range includes more than 250 gun types for Colour, In Line, Mono and Display Tubes along with Mount Parts, Bases, Getters, Sealoffs, and all other associated items for TV Tube Production.

A Full Technical Back-up and Advisory Service is available to all customers Worldwide.

Please request our current catalogues and Data Information.

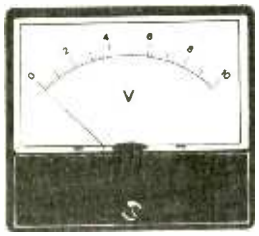
GRIFTRONIC EMISSION LTD

2 SWAN STREET
ALCESTER
WARWICKSHIRE
B49 5DP
ENGLAND

Telephone: (0789) 764852/764100. Telex: 312354 Grifem G

WW – 006 FOR FURTHER DETAILS

METER PROBLEMS?



137 Standard Ranges in a variety of sizes and stylings available for 10-14 days delivery. Other Ranges and special scales can be made to order.

Full Information from:

HARRIS ELECTRONICS (London)

138 GRAY'S INN ROAD, W.C.1
Phone: 01-837 7937
Telex: 892301

WW – 015 FOR FURTHER DETAILS

Midwich

EAST ANGLIA'S LEADING SUPPLIER OF MICROCOMPUTERS AND COMPONENTS TO EDUCATIONAL ESTABLISHMENTS.

BBC Microcomputers

Model B	346 95
Model B + Disc Int	431.95

NB Credit cards are not accepted in payment for BBC Microcomputers

BBC Micro Econet

Full range of products available Installation service available

BBC Compatible Disc Drives

Cased drives, finished to match the BBC Micro are supplied complete with connecting cables, manual and utilities disc

All single cased drives may be expanded to dual configuration by the addition of the appropriate uncased mechanism

Disc capacity	Single	Dual	Uncased
100K	195 00	335 00	142 00
200K	235 00	449 00	216 00
400K	290 00	545 00	260 00

Trade/quantity discounts are available

BBC Micro Upgrade Kits

BBC A2B Complete A TO B	44 75
BBC3 Disc Interface	84 95

Fitting service available

BBC Micro Connectors

BBC21 Printer Cable	7 50
BBC22 User Port Connector & Cable	2 45
BBC23 Cassette Lead	3 50
BBC24 7 Pin Din Plug	0 60
BBC25 6 Pin Din Plug	0 60
BBC26 5 Pin Din Plug	0 60

BBC Micro Accessories

BBC45 Joysticks	11 30

BBC Micro Software

View Wordprocessor	52 00
1 2 MOS	10 00

BBC Micro Software

Full range available Please telephone for stock position

Memories

2114L-200NS	D1	0 80
2708 450NS	D2	2 95
2716 450NS	D1	2 45
2716 350NS	D1	4 95
2716 3 Rail	D1	7 25
2532 450NS	D2	3 45
2732 450NS	D1	3 45
2732 350NS	D1	5 45
2764 300NS	D1	7 95
4116 150NS	D1	0 85
4116 200NS	D2	0 80
4118 150NS	D1	3 25
5516 200NS	D2	9 45
6116 150NS	D1	3 30
6116 Low Power 150NS	D2	4 95
4164 200NS TI	D3	3 95
4164 200NS NEC	D3	3 95
4516/4816 100NS	D2	2 25
4532 200NS	D2	2 95

6800 Family

6800	D7	2 25
6802	D5	2 50
6809	D6	6 30
6810	D1	1 15
6821	D3	1 00
6840	D4	3 75
6845	D5	6 50
6850	D2	1 10
68488	D2	7 30
68B00	D7	5 25
68B09	D6	12 00
68B10	D1	2 26
68B21	D3	2 20
68B40	D4	6 00
68B50	D2	2 20

Z80 Family

Z80 ACPU	D2	2 99
Z80 BCPU	D2	9 00
Z80 ACTC	D1	2 60
Z80 BCTC	D1	9 00
Z80 ADART	D1	5 60
Z80 ADMA	D2	6 95
Z80 AP10	D1	2 75
Z80 BP10	D1	9 00
Z80 AS10	D4	9 00

8080 Family

8085A	D4	3 50
8212		1 10
8216		1 00
8224		2 10
8228		3 27
8251A	D5	2 50
8253		4 00
8255A	D5	2 25

6500 Family

6502	D3	3 25
6502A	D3	5 00
6520	D1	2 50
6520A	D1	3 16
6522	D5	3 00
6522A	D5	5 50
6532	D2	5 50

Floppy Disc Controllers

8271		48 00
FD1771	D5	15 00
FD1791	D6	22 00
FD1783	D6	23 00
FD1795	D6	28 00
FD1797	D6	28 00
WD1691	D2	12 00
WD2143-01	D2	6 99

Buffers

81LS95	0 80
81LS96	0 80
81LA97	0 80
81LS98	0 80
8T26A	0 90
8T28A	0 90
8T95	0 90
8T97A	0 90
8T98	0 90

Interface Devices

6402		3 80
75107		0 47
75110		0 56
75150		0 64
75154		0 77
75160		2 56
75161		2 80
75162		3 95
75172		1 95
75173		1 44
75174		1 95
75175		1 44
75182		0 50
75183		0 50
75188		0 37
75189		0 37
75451		0.22
75452		0 22
75453		0 22
75454		0 22
75468		0.88
75491		0 31
75492		0 42
AY31015	D2	3 00
AY31270		6 47
AY38910	D6	4 40
AY53600	D2	6 70
DP8304	D1	2 50
MC1488	D1	0 37
MC1489	D1	0 37
NC3242A		6 30
MC3446	D1	2 50
MC3448A	D1	3 75
MC3480	D5	7 30
MC3487	D1	2 00
MC14411	D1	7 65
MC14412		9 45
RO32513L	D1	6 50
RO32513U	D1	6 50

UHF Modulators

UM1111 6MHz	D1	2 50
UM1233 8MHz	D1	3 30

Linears

L203	0 65
LF398N	4 75
LM301AN	0 24
LM308N	0 48
LM311P	0 50
LM319N	1 99
LM324N	0 30
LM348N	0 60
NE555P	0 16
NE556CP	0 45
TL010	0 39
TL061	0 29
TL062	0 49
TI064	0 98
TL066	0 29
TL071	0 29
TL072	0 47
TL074	1 00
TL081	0 26
TL082	0 46
TL084	1 58
TL091	0 40
TL092	0 58
TL094	1 34
TL487	0 62
TL489	0 62
TL494	1 63
TL496	0 60
TL507	1 33
725	1 60
741	0 14
747	0 48
748	0.27

Regulators

78L05	0 30
78L12	0 30
78L15	0 30
7805	0 40
7812	0 40
7815	0 40
7905	0 45
7912	0 45
7915	0 45
LM309K	1 20
LM317K	2 40
LM323K	4 50
LM338K	6 25

Data Convertors

UPD7002	D1	4 26
ZN425	D1	3 45
ZN426	D1	3 00
ZN427	D1	5 99
ZN428	D1	4 75
ZN429	D1	2 10
ZN432	D1	13 00
ZN449	D1	2 55

Crystals

1MHz	2 75
1 8432 MHz	1 92
4MHz	0 64
8MHz	0 86

DIL Sockets

Pins	Tin	Gold	W/W
8	7	16	25
14	10	26	35
16	10	29	40
18	13	33	50
20	15	37	60
22	17	38	65
24	21	46	70
28	24	55	80
40	30	76	99

ZIF Sockets

24 Pin	5 75
28 Pin	8 20
40 Pin	9 75

Data sheets are available on items marked D.

Prices are as follows

D1	0.75	D5	2.00
D2	1.00	D6	3.00
D3	1.25	D7	4.00
D4	2.00	D8	5.00

A full range of the following products is carried in stock and is listed in our FREE catalogue

- ★ 74LS Series TTC
- ★ 4000 Series CMOS
- ★ TI Bipolar Memories
- ★ 9900 Series Micros
- ★ Crystals
- ★ IDC, Card Edge & D-Type Connectors
- ★ Dip Jumpers
- ★ Monochrome & Colour Monitors (NEC & KAGA)
- ★ Eprom Programmers & Erasers
- ★ Custom Cable Assemblies

SPECIAL OFFER! SPECTRUM 32K UPGRADE KIT £24 95

Carriage Orders up to £199 are sent by 1st class post and £200+ by Secuncor
0-£100 0 50 £100-£199 1 25 £200+ 5 00 by Secuncor
Prices quoted (+ carriage charges) are exclusive of VAT and are subject to change without notice
Quantity Discounts are available on many products, please ring for details
Official Orders are welcome from Education Establishments, Government Bodies and Public Companies
Credit Accounts are available to others subject to status Payment is due strictly nett by the 15th of the month
Credit Cards are accepted (Access and Visa) for telephone and postal orders and NO SURCHARGE is made
Out of stock items will follow automatically, at our discretion, or a refund will be given if requested

FOR FAST, IMMEDIATE SERVICE YOU CAN TEL. YOUR ORDER TO:
DISS (0379) 898751
Midwich Computer Company Limited, Rickinghall House, Hinderclay Rd, Rickinghall, Suffolk IP22 1HH.

For more information about the hardware and software available send for our **FREE CATALOGUE**
Post to Midwich Computer Company Limited, Rickinghall House, Hinderclay Road Rickinghall, Suffolk IP22 1HH

Name
Address
Postal Code
Telephone WW

WW – 034 FOR FURTHER DETAILS

www.americanradiohistory.com

P. F. RALFE ELECTRONICS

10 CHAPEL STREET, LONDON, NW1 TEL: 01-723 8753

★ MARCONI SIGNAL GENERATORS ★

TF2002A/S (illustrated) 10kHz-72MHz. AM/FM. **£750**
TF2002. As above but AM only. **£450**
MARCONI TF1066B. AM/FM Generator. 10-470MHz. 0.2uV-200mV output. FM Deviation up to ±100kHz.
MARCONI TF995A/5. AM/FM Generator. Narrow deviation model 995 covering 1.5-220MHz. **£450**. TF2015. 10-520MHz. AM/FM. TF144H. AM 10kHz-72MHz **£295**.
MARCONI TF1064B/5. AM/FM Signal generator covering in three ranges 68-108, 118-185 and 450-470MHz. FM fixed deviations of 3.5 & 10kHz. AM fixed 30%. **£225**

★ 'DOLBY' NOISE WEIGHTING FILTERS ★

Cat. No. 98A. Noise weighting filters for CCIR/ARM signal-to-noise ratio measurements. As new units. **£40** each (+£1 p&p).

BECKMAN TURNS COUNTER DIALS

Miniature type (22mm diam.). Counting up to 15 turn "Helipots". Brand new with mounting instructions. Only **£2.50** each.

RFI RECEIVER

Stoddart Model NM52A. RF Noise & Field intensity measuring receiver. 375MHz-1GHz c/w power supply unit.

KAY SOUND SPECTROGRAPH

Model 6061B with Amplitude Display, scale magnifier. 85Hz-16kHz. Complete sound spectrograph in excellent condition.

★ AUDIO WATTMETERS ★

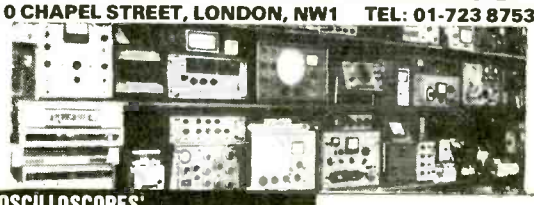
Switchable 1W & 10W FSD. Internal 3.5 & 8 Ohm load impedances. Housed in grey enamelled case 6×6×3". Large easy to read 3" sq. meter. Scope output provision. **£10** (+£1).
HEATHKIT Model AW-IU. Internal load switchable 3, 8, 15 & 600 Ohm. Meter scaled 0-50W (+dB scale). 5 Ranges from 5mW-50W FSD. Mains powered. **£25** (+£1).
MARCONI TF893A. 1mW-10W Full scale in 5 ranges. Impedances 2.5-20K Ohm in 48 steps. Direct calibration in Watts and dBm. **£85** (+£2).

GPO JACK SOCKET STRIPS. 20-WAY Type 320 (3-pole) **£2.50** ea. Type 520 (3-pole with switching contacts) **£4** ea. Please include 35p each for postage on these. GPO type 316 jack plugs for above **20p** ea. (10+ post free). Plus VAT please. Also recent stock of new, mint condition 720 Type, £6 each.

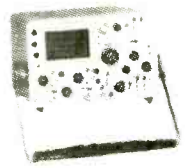
★★ CONSTANT VOLTAGE TRANSFORMERS ★★

'ADVANCE VOLSTAT'; Type. Model MT140A. Mains input 190-260V AC. Output 230V AC @ 150W. Price each **£20** + VAT + £2 carriage.

'OSCILLOSCOPES'



TEKTRONIX 453. Dual-trace 50MHz.
TEKTRONIX 565. Dual time-base. Differential plug-ins.
SOLARTRON CD1740. 50MHz sweep-delay **£350**.
MARCONI TF2210. Dual-trace, 100MHz, sweep-delay **£350**.
DYNAMCO D7200 Mains/Battery portable. Dual-trace 15MHz **£225**.



N.B. We have a frequent stock turnover of good, used 'scopes. Should you have a specific requirement for any item of test equipment we would be pleased to receive your enquiry.

MARCONI TF2502 RF Power meters. DC-1GHz. 10w fsd **£350**.
MARCONI TF2701 In-Situ Universal component Bridge **£250**.
MEGGER-5KV Insulation tester. Hand-crank.
PHILIPS Model PM8041. X-Y Recorder.
MARCONI TF2343A Quantization Distortion Meter **£150**.
HEWLETT-PACKARD 3450A Multi-Function Digital Multi-Meter.
ROHDE & SCHWARZ 'SDR' AM signal generator 0.3-1GHz.
HEWLETT-PACKARD 608C. AM signal generator 10-480MHz.
TGL Spectrum Analysers model SA102. 0-500MHz. Brand new factory units. 0-500MHz. Send for specifications.

★ INSULATION TESTERS ★

Transistorised 'Metrohm' 250V & 500V **£40**
Transistorised 'Megger' 500V **£60**
Hand-Crank 'Megger' 500V **£60**
Supplied in fully tested excellent condition

★ DISC CARTRIDGES ★

BASF 12-Segment Single Hard Disc Cartridges. Brand new surplus stock. **£20 ea.**

★ SWEEPERS ★

TELONIC Sweep generator system type 2003. Fitted with Marker, attenuator, Detector plug-in units and Generator covering 800-1500MHz. **£325**

★ MUIRHEAD FACSIMILE UNITS ★

MUFAX 'COURIER' facsimile receiver type K441-CH and transmitters K400 AMCH in stock in excellent condition **£250** per pair.

PLEASE NOTE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry a three months' guarantee. For our mail order customers we have a money-back scheme. Repairs and servicing to all equipment at very reasonable rates. PLEASE ADD 15% VAT TO ALL PRICES.

★ DC POWER SUPPLIES ★

APT. Ex-computer supplies. Program variability 6-30V DC (secondary taps & resistor). Connections supplied. Three sizes available, 5A, 7½A & 10A. Prices **£20**, **£25**, and **£30** respectively (p&p £3.50).
FARNELL. Current limited. 13-17VDC @ 2A **£15**. 27-32V @ 1A **£10**. 12V @ 1A **£10** (+ £1.50 p&p).
COUTANT 5V @ 5A (7 x 5 x 3"). **£20** (+ £1 p&p).
VARIABLE 0-30V @ 1A. Volt-metered. **£25** (+ £1).
FARNELL 5V switching @ 60 Amps. (Measures 13 x 5 x 6"). Recent special purchase **£50** only (+ £3 p&p).
MULLARD Dual ±12V @ 1A @ 0.4A, **£10** (+£1).

★★ STEPPER MOTORS ★★

Brand new stock of 'ASTROSYN' Type 20PM-A055 stepper motors. 28V DC. 24 steps per rev. 15 oz-in torque @ 100PPS. Body length 2½", diameter 2", shaft ¼" diam × 4¼" spirally threaded. Weight 16oz. Price each **£15** (p&p 50p). Connections supplied.

★ MILLI-VOLT MEASUREMENT, ANALOGUE ★

MARCONI TF2600. Twelve ranges 1mV-300V FSD. Wide-band to 10MHz.
MARCONI TF2603. Frequency range 50kHz-1.5GHz. High Sensitivity from 300uV.
MARCONI TF2604. Electronic Multi-meter. AC/DC 300mV Full scale to 300V (1kV DC). Resistance ranged. AC Frequency range 20Hz-1500MHz.

★ BRUEL & KJAER ★

Model 2006 Heterodyne Voltmeter. AM/FM/ Voltage measurements to 240MHz.

CLAUDE LYONS 240V AC REGULATORS

Small quantity available of constant voltage mains regulators. Continuous current rating 5A. Model no. CVR-1200. Input 204-252V. Output adjustable 200-254V AC± 0.3%. 45-65Hz. Condition as new. (Dims – 11"×7"×6". Weight 20Kgs). **Price £95 ea. + Carriage £5.**

ROTRON INSTRUMENT COOLING FANS

Supplied in fully tested excellent condition as follows:
115V, 4½x4½x1½" **£5**. 230V same size **£5.50**. 115V 3x3x1½" **£4**. 230V 3" size, brand new **£6**. Also small quantity 115V 4½" size, brand new **£6**. Postage each + 50p please.

WW-10

ICOM ICR70

The professional communications receiver for point to point, ship to shore, and general coverage radio work. RANGE 100KHz-30MHz ★ MODES AM, SSB, CW, RTTY and optional FM ★ CPU based 10Hz step digital PLL synthesizer with DUAL VFO's ★ Frequency display 6 digit to 100Hz ★ STABILITY less than 50Hz after one hour ★ POWER SUPPLY 117 or 235V AC and optional 12V DC ★ IF – 1st 70.4515MHz, 2nd 9.0115MHz, 3rd 455KHz, 4th 9.0115MHz ★ Optional transceive units and filters available.

THIS SUPERB RECEIVER IS PRICED AT

£433.91 + VAT

Contact us for more details on this and other ICOM professional communications equipment.

PMR – MARINE – AMATEUR

Dealer enquiries welcome

Thanet Electronics ICOM

143 Reculver Road, Herne Bay, Kent
Tel: 02273 63859. Telex 965179

WW – 039 FOR FURTHER DETAILS

Keep those Contacts CLEAN

BY USING A

DIACROM SPATULA

Manufactured in France
British Patents applied for

No other cleaner has all these advantages:—

1. Only 100% pure, natural diamond grains are utilised
2. Blades are treated with hard chrome to reinforce the setting of the diamond grains to obviate loosening or breakaway during use. This process also prevents clogging of the diamonded surface by residues resulting from use
3. All diamonded blades are rectified to ensure an absolutely smooth surface by eliminating diamond grains which may rise above the surface. This eliminates all excessive scratching during use.
4. All diamond grains are rigidly calibrated to ensure a perfectly uniform grain size of either 200, 300 or 400
5. The chrome gives a very weak co-efficient of friction and the rigidity of the nylon handle is calculated to permit proper utilisation and yet pliant enough to avoid undue pressures on highly delicate relays

- Grain size 200 thickness 55/100 mm both faces diamonded. For quick cleaning of industrial relays and switching equipment, etc
- Grain size 300 thickness 55/100mm both faces diamonded. For smaller equipments like telephone relays, computer relays, etc.
- Grain size 400 thickness 25/100 mm one face diamonded. For sensitive relays and tiny contacts. Two close contacts facing each other can be individually cleaned, because only one face of the spatula is abrasive.

Sole Distributors for the United Kingdom
SPECIAL PRODUCTS (DISTRIBUTORS) LTD
81 Piccadilly, London W1V 0HL. Phone: 01-629 9556
As supplied to the M.O.D., U.K.A.E.A., C.E.G.B. British Rail and other Public Authorities; also major industrial and electronic users throughout the United Kingdom.

WW – 035 FOR FURTHER DETAILS

www.americanradiohistory.com

THE COMPLETE PACKAGE! MICROPROFESSOR PLUS THE STUDENT WORK BOOK

A low cost tool for learning, teaching and prototyping.

Micro-professor is a low-cost Z80 based micro computer which provides you with an interesting and inexpensive way to understand the world of microprocessors.

Micro-Professor is a complete hardware and software system and is a superb learning tool for students, hobbyists and microprocessor enthusiasts, as well as an excellent teaching aid for instructors of electrical engineering and computer science courses.

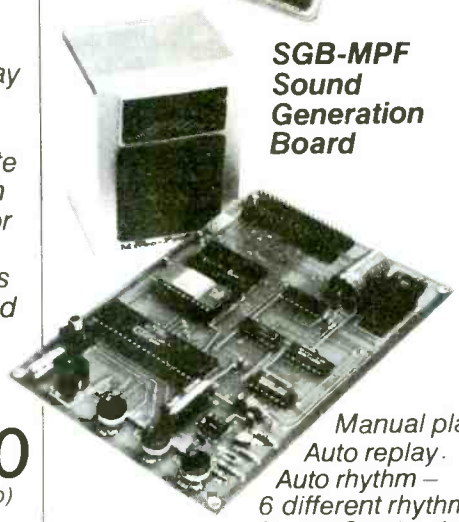
Micro-Professor **£99·50** *(+£4.00 p&p)*

Now with the Student Work Book available Flight offer you the complete package. An easy to follow manual that will help further your understanding of microprocessors.

Student Work Book **£16·00**

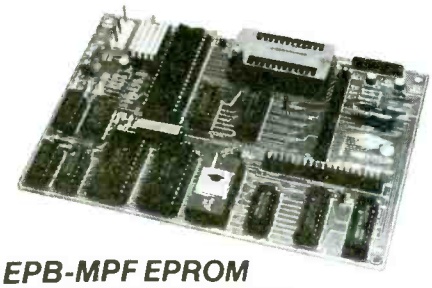
FLIGHT Electronics Ltd.

Micro-Professor is a trade mark of Multitech Industrial Corporation. Z80 is a trade mark of Zilog Inc.



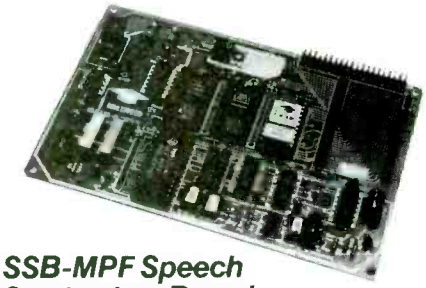
SGB-MPF Sound Generation Board

Manual play, Auto replay. Auto rhythm – 6 different rhythms, Sound Synthesizer and Hi-fi speaker.



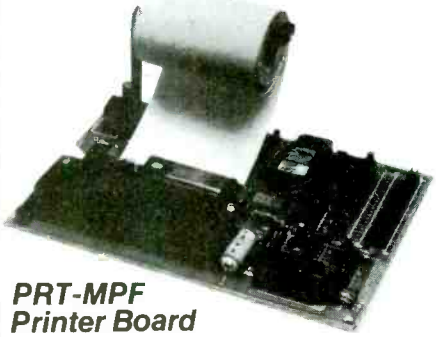
EPB-MPF EPROM Programming Board

For all + 5V 1KB/2KB/4KB EPROMS Read/Copy/List/Verify Capability.



SSB-MPF Speech Synthesizer Board

A vocabulary of up to 400 words based on the TMS 5200 chip.



PRT-MPF Printer Board

Memory dump utility. BASIC program listing. Z80 disassembler.

Please send me		*Qty*
Micro-Professor	*£99.50 (+£4.00 p&p)*	
Student Work Book	*£16.00*	
SGB-MPF board	*£79.50*	
EPB-MPF board	*£99.50*	
SSB-MPF board	*£99.50*	
PRT-MPF board	*£86.25*	

I enclose cheque/P.O. for £.....

Name .....

Address .....

.....

.....

Mail Order only
Prices include VAT. Please allow 28 days for delivery.

By phone or post

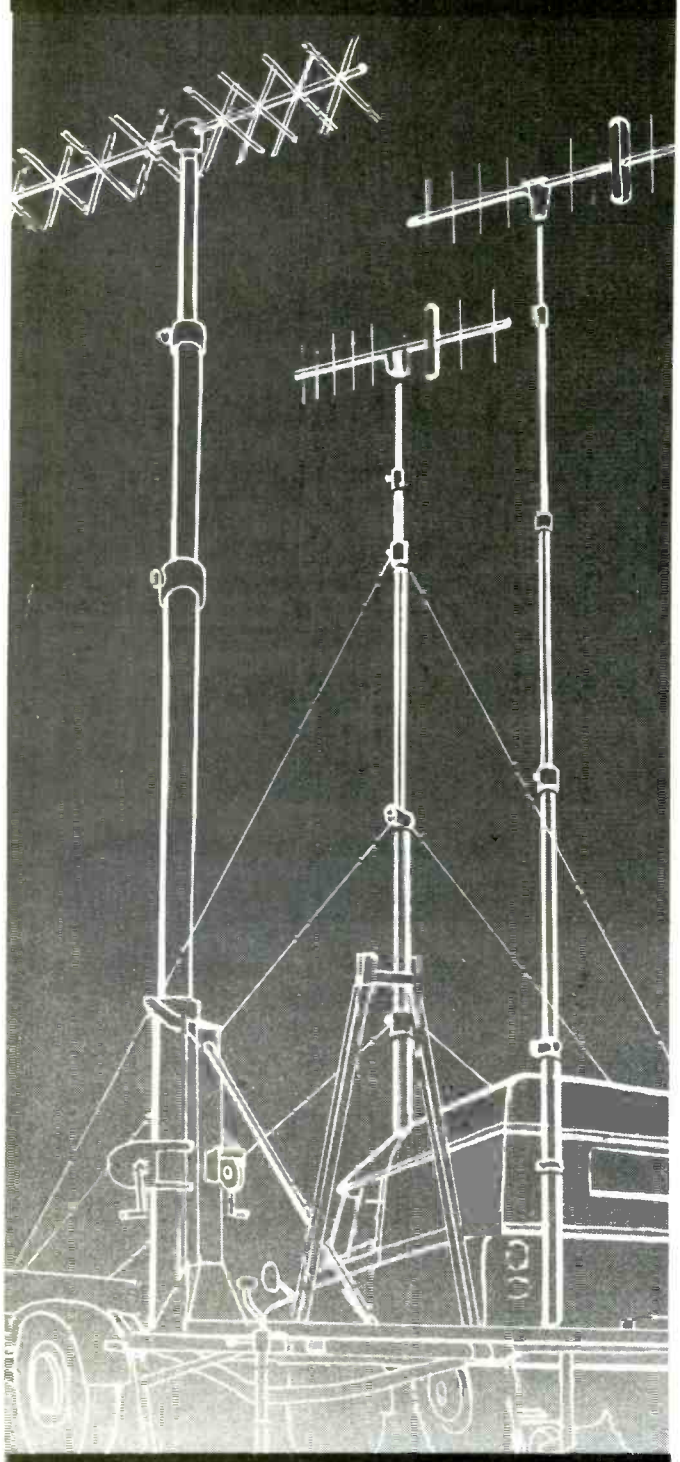
FLIGHT ELECTRONICS LTD.
Quayside Rd. Southampton, Hants SO24AD. Telex. 477793.
Tel. (0703) 34003/27721.

WW – 017 FOR FURTHER DETAILS

www.americanradiohistory.com

TELESCOPIC MASTS

Pneumatically operated telescopic masts. 25 Standard models, ranging from 5 metres to 30 metres.



Hilomast Ltd

THE STREET HEYBRIDGE — MALDON
ESSEX CM9 7NB ENGLAND
Tel. MALDON (0621) 56480
Telex No. 995855

WW – 010 FOR FURTHER DETAILS

Essex Tiny Basic System

The Essex Tiny Basic Computer is an ideal choice for data acquisition and process control systems. Its crystal controlled timer and interrupts provide accurate timing and fast response to critical events, while the watchdog timer ensures reliable operation. Programs can be entered and tested from an RS232 terminal, and then be copied into EPROM. Alternatively, Instant ROM modules may be used both during development and for program storage.

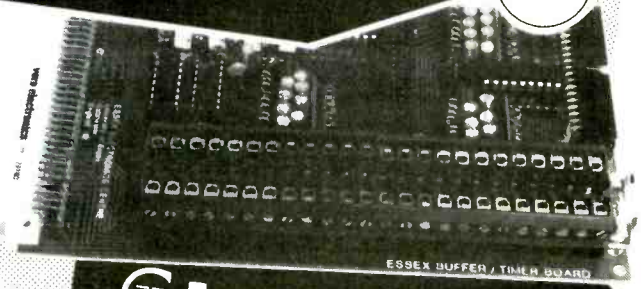
INSTANT ROM is the trademark of Greenwich Instruments

£185

Essex Buffer Timer

A convenient means of buffering the I/O lines of the Essex Tiny BASIC Computer provides 24 inputs, 16 outputs and four hardware timers.

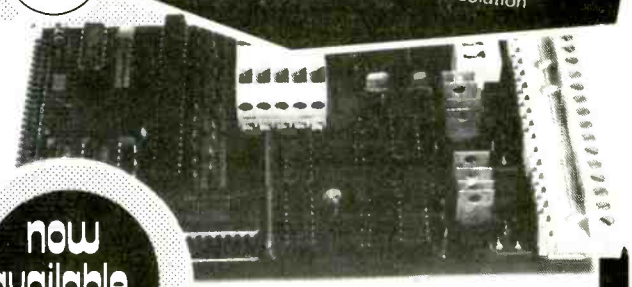
£78



Essex Opto-Isolator

Connects to the Essex Tiny BASIC System bus to provide an additional 12 opto-isolated inputs and 12 opto-isolated outputs per card for safe connection to external equipment, isolation voltage = 1500 volts

£150



now available...

Essex Backplane

A four slot backplane with printer and terminal connectors to accept these cards. £35

'Alex'

A powerful software utilities package that provides the user with an enhanced editor and all the tools needed to program efficiently in assembly language.

* Text Editor * Assembler
* Disassembler * Debug Monitor £65

Supplied as a 4K EPROM with comprehensive manual.

all prices exclude V.A.T.
*
substantial quantity discounts available
*
carriage within U.K. £2

Essex Electronics Centre

Wivenhoe Park, Colchester, Essex CO4 3SQ
Telephone: Colchester (0206) 865089

WW – 026 FOR FURTHER DETAILS

www.americanradiohistory.com

LOOK AHEAD!

MONOLITH
electronic products

WITH MONOLITH MAGNETIC TAPE HEADS –

VIDEO HEAD REPLACEMENT KIT

DOES YOUR VCR GIVE WASHED OUT NOISY PICTURES – IT'S PROBABLY IN NEED OF A NEW HEAD – FAST FROM OUR *EX-STOCK* DELIVERIES.

SAVE £££'s ON REPAIR CHARGES.

OUR UNIVERSAL REPLACEMENT VIDEO HEADS FIT ALL MODELS OF VHS OR BETAMAX VCR's. FOLLOWING OUR REPLACEMENT GUIDE AND WITH A PRACTICAL ABILITY, YOU CAN DO THE WHOLE JOB IN YOUR OWN HOME WITH OUR HEAD REPLACEMENT KIT.

HOW TO ORDER,

PLEASE STATE CLEARLY THE MAKE AND MODEL OF YOUR RECORDER. THERE ARE TWO VERSIONS OF THE VHS HEAD AND YOUR ORDER CAN BE PROCESSED FASTER IF YOU CHECK THE SIZE OF THE CENTRE HOLE OF THE HEAD WHICH WILL BE EITHER 5mm OR 15mm DIAMETER.

CATALOGUE

For our full Catalogue of Replacement Video and Audio Cassette/Reel to Reel Heads, Motors, Mechanisms etc. Please forward 50p P. & P.

KIT CONTAINS – NEW VIDEO HEAD, 5 CLEANING TOOLS, HEAD CLEANING FLUID, CAN OF AIR BLAST, INSPECTION MIRROR, ANTISTATIC CLOTH, VHS/BETAMAX MAINTENANCE MANUAL, CROSS HEAD SCREWDRIVER, HANDLING GLOVES, MOTOR SPEED DISC, SERVICE LABEL, HEAD REPLACEMENT GUIDE.

VHS KITS £53.25
BETAMAX KIT £65.25
Prices include P. & P. and V.A.T.

THE MONOLITH ELECTRONICS CO. LTD
5-7 Church Street, Crewkerne, Somerset TA18 7HR, England
Telephone Crewkerne (0460) 74321
Telex 46306 MONLTH G

MONOLITH THE SPECIALISTS
SUPPLIER TO MOST OF THE U.K.'s LEADING DISTRIBUTORS AND SERVICE ORGANISATIONS

WW – 012 FOR FURTHER DETAILS

GSC announce two NEW handheld instruments

COMBINES THE PERFORMANCE OF BENCHTOP MODELS WITH THE CONVENIENCE OF PORTABLE UNITS

3002 AUTO-RANGING CAPACITANCE METER

In the palm of your hand – a capacitance meter that behaves like a benchtop model. Just look at the features that GSC have built into the Model 3002:

- 3½-digit liquid-crystal display
- Eight ranges from 1pf to 19 990 uF
- Dual-threshold technique for high accuracy
- Accuracy down to 0.2%
- Measures only 193 x 95 x 44mm
- Battery or mains operation

And that's not all – because the 3002's d.c. charging characteristics allow it to determine the true capacitance of cables, switches and other componerts as well as capacitors. All this – plus the option of rechargeable battery or mains operation – for only £144.

5000 COUNTER-TIMER

GSC's new Model 5000 counter-timer sets new standards in hand-held electronic instrumentation.

Why? – because the 5000 not only incorporates the latest developments in high-speed low-power C-MOS circuitry to pack benchtop features into a pocket-sized instrument – it also adds extra features like pulse-width measurements, signal conditioning, and automatic master reset logic to eliminate erroneous readings.

The cost? Only £239 – and this buys you a full 0.1Hz-50MHz instrument in a package measuring only 193 x 95 x 44mm. The 5000 also offers the option of mains or rechargeable battery operation, and it's so easy to operate.

Has there ever been a better bargain?

GLOBAL SPECIALTIES CORPORATION

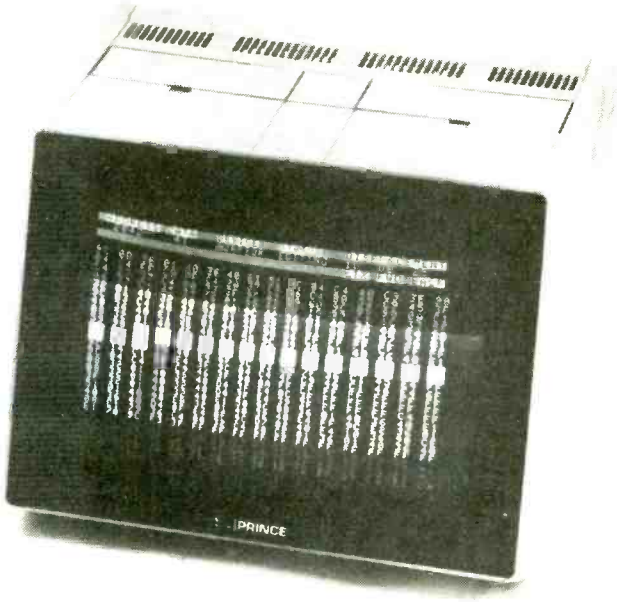
GSC (UK) Limited
Freepost-Saffron Walden, Essex CB11 3AQ Tel: Saffron Walden (0799) 21682 Telex: 817477

WW – 054 FOR FURTHER DETAILS

www.americanradiohistory.com

EP8000 EPROM EMULATOR PROGRAMMER

NEW PRODUCT



The new microprocessor controlled EP8000 Emulator Programmer will program and emulate all EPROMs up to 8k x 8 sizes, and can be extended to program other devices such as 16k x 8 EPROMs, Bipolar PROMs, single chip microprocessors with external modules.

Personality cards and hardware changes are not required as the machine configures itself for the different devices.

The EP4000 with 4k x 8 static RAM is still available with EPROM programming and emulation capacity up to 4k x 8 sizes.

FEATURES

- Software personality programming/emulation of all EPROMs up to 8k x 8 bytes including 2704, 2708, 2716(3), 2508, 2758A, 2758B, 2516, 2716, 2532, 2732, 2732A, 68732-0, 68732-1, 68766, 68764, 2564, 2764. Programs 25128, 27128 with adaptors.
- No personality cards/characterisers required.
- Use as stand alone programmer, slave programmer, or EPROM development system.
- Checks for misplaced and reversed insertion, and shorts on data lines.
- Memory mapped video output allows full use of powerful editing facilities.
- Built-in LED display for field use.
- Powerful editing facilities include: Block/Byte move, insert, delete, match, highlight, etc.
- Comprehensive input/output – RS232C serial port, parallel port, cassette, printer O/P, DMA.
- Extra 1k x 8 scratchpad RAM for block moving.

● EP8000 8k x 8 Emulator Programmer – £695 + £12 delivery ● BSC8 Buffered emulation cable – £49 ● SA27128 Programming adaptor – £69 ● SA25128 Programming adaptor – £69 ● EP4000 4k x 8 Emulator Programmer – £545 + £12 delivery ● BSC4 Buffered emulation cable – £39 ● BP4 (TEXAS) Bipolar PROM Module – £190 ● Prinz video monitor – £99 ● UV141 EPROM Eraser with timer – £78 ● GP100A 80 column printer – £225 ● GR1 Centronics interface – £65

VAT should be added to all prices

DISTRIBUTORS REQUIRED ● EXPORT ENQUIRIES WELCOME

GP Industrial Electronics Ltd. Tel: Plymouth (0752) 332961 Telex: 42513

Unit E, Huxley Close, Newnham Industrial Estate, Plymouth PL7 4JN

WW – 040 FOR FURTHER DETAILS

www.americanradiohistory.com

P8000 — THE PRODUCTION PROGRAMMER THAT HANDLES ALL NMOS EPROMS

NEW PRODUCT

- Checks, Programs, Compares up to 8 devices simultaneously
- Handles all NMOS EPROMS up to projected 128K designs with no personality modules or characterisers — See list
- Easy to use, menu driven operation for blankcheck, program, verify, illegal bit check, checksum, self-test
- Constant display of device type, mode and fault codings
- Individual socket LED indicators for EPROM status
- Comprehensive EPROM integrity checks — Illegal bit check, data and address shorts, constant power line monitoring
- Full safeguard protection on all sockets
- Automatic machine self-test routine
- RS232C interface supplied as standard
- Powered down sockets
- Cost effective price — £695 + VAT
- Available from stock

2704
2708
2716(3)
2508
2758A
2758B
2516
2716
48016
2532
2732
2732A
68732-0
68732-1
68766
68764
2764
2564
MK2764
25128
27128

Write or phone for more details

DISTRIBUTORS REQUIRED ● EXPORT ENQUIRIES WELCOME

GP Industrial Electronics Ltd.

Tel: Plymouth (0752) 332961
Telex: 42513

Unit E, Huxley Close, Newnham Industrial Estate, Plymouth PL7 4JN

WW – 040 FOR FURTHER DETAILS

www.americanradiohistory.com

CRICKLEWOOD ELECTRONICS LTD.

40 Cricklewood Broadway, London NW2 3ET. Tel. 01-452 0161. Tlx. 914977.

Here's a selection from our vast stocks. Full price list free on request. Orders by 'phone quoting credit card no. or by mail order. Callers welcome. **All products first grade franchised source** All in stock items despatched same day. Official orders welcome from Govt. Depts, schools, etc. Please add 60p p&p + 15% VAT. Overseas orders no VAT but allow £2.00 min. p&p. Quantity discounts negotiable.

Stocking parts other stores cannot reach!

RESISTORS

CARBON FILM 5% HI-STAR LOW NOISE
10Ω to 10MΩ
¼W E24 2p
½W E24 2½p
1W E12 6p
2W E12 12p

METAL FILM ULTRA STABLE 0.4W EXTRA LOW NOISE
10Ω to 1MΩ
2% E24 5p
1% E24 6p

LOW OHMIC GLAZE ½W
0.22Ω to 8.2Ω
E24 11p

WIREWOUND ON CERAMIC E12 SERIES
2 to 3 WATT
0.22Ω to 330Ω 28p
4 to 7 WATT
0.47Ω to 6k8 33p
10 to 11 WATT
1Ω to 33K 37p

POTS & PRESETS

ROTARY POTS LOW NOISE ¼" SPINDLES
E3 SERIES
4K7 to 2M LIN 32p
4K7 to 2M LOG 32p
As above with DP mains switch 79p
As above stereo (no switch) 89p

PRESETS PIHER (DUSTPROOF)
E3 100Ω to 10MΩ
Mini Vertical 15p
Mini Horizontal 15p
Standard Vert 18p
Standard Horiz 18p

CERMET 20 TURN PRECISION PRESETS
¾" E3 Series
50Ω to 500K 89p

CAPS

CERAMIC 100V DISC (PLATE) E12 MICRO MINI
typically +5%
1pF to 10nF 7p

POLYCARB 5% SIEMENS 7.5mm MINI BLOC E12 250V
1nF to 6n8 7p
8n2 to 47nF 8p
56nF to 150nF 10p
100nF 7p
100nF to 150nF 11p
180nF to 270nF 14p
330nF to 390nF 20p
470nF to 560nF 26p
680nF 30p
1μF (10mm) 35p

POLYESTER 250V RADIAL (C280)
10nF 15nF 22nF 33nF 47nF 68nF 100nF 7p
150nF 220nF 10p
330nF 470nF 13p
680nF 18p
1μF 22p
1μ5 2μ2 39p

FEEDTHROUGH
1nF 500V 7p

HIGH VOLTAGE Capacitors
please enquire many types in stock

TANT BEADS
1 35V 14p
2.2 35V 14p
3.3 35V 14p
4.7 35V 14p
6.8 35V 14p
10/16V 18p
10/35V 22p
15/10V 22p
15/16V 30p
15/25V 32p
22/6.3V 26p
22/16V 29p
33/10V 30p
47/3V 14p
47/6.3V 34p
47/16V 39p
100/13V 32p
100/10V 55p

ELECTROLYTICS
Mainly Matsushita (Panasonic) & Siemens
AXIALS (Wires each end)

μFd	V	
47	63	8p
47	100	9p
47	350	30p
1	63	8p
1	100	9p
1	500	40p
2.2	25	8p
2.2	63	9p
2.2	100	11p
2.2	350	30p
3.3	25	10p
3.3	40	11p
3.3	63	12p
4.7	16	8p
4.7	25	9p
4.7	40	11p
4.7	63	12p
4.7	100	14p
10	25	8p
10	40	12p
10	63	14p
10	100	16p

μFd	V	
22	25	11p
22	40	14p
22	63	16p
22	100	21p
47	25	14p
47	40	17p
47	63	26p
47	100	28p
100	16	14p
100	25	16p
100	40	22p
100	63	25p
100	100	30p
220	10	16p
220	16	17p
220	25	22p
220	40	25p
220	63	30p
220	100	40p
470	16	22p
470	25	28p
470	40	33p
470	63	43p
470	100	60p
1000	16	30p
1000	25	38p
1000	40	46p
1000	63	65p
2200	16	40p
2200	25	63p
2200	40	70p
2200	63	134p
4700	16	75p
4700	25	89p

RADIALS (PCB wires one end) Matsushita only

μFd	V	
10	16	6p
22	16	6p
22	25	7p
47	10	7p
47	16	8p
100	10	9p
100	16	10p
220	10	11p
220	16	12p
470	10	17p
470	16	18p
1000	10	20p
1000	16	24p
2200	10	34p
2200	16	44p

TRANSFORMERS

All 240V Primary
6.0 6V 9.0 9V
12.0 12V
15.0 15V
100mA 95p
1A 2.65
20.0 20V
1.25A £2.65
12.0 12.0
50VA 4.35
12.0 12.0
100VA 8.95
0 6 6 9 9
1.25A 4.25
These goods are heavy send extra p&p. We will credit any difference

VERO

0.1" COPPER TRACKS
2.5 3.75 83p
2.5 5 99p
3.75 3.75 99p
3.75 5 1.14
2.5 17 2.99
3.75 17 3.85
4.79 17 4.93
VQ Board 1.92
Dip Board 3.90
Track Cutter 1.48
100 Pins 55p
Veroblock 3.99

Vero Wiring
Pen + Spool 3.35
Spare Spool 75p
Combs 6p

PCB MATS

FERRIC CHLORIDE
Quick dissolving pellets (mix with 1 litre water) 1.69

ETCH RESIST TRANSFERS
1 Thin lines
2 Thick lines
3 Thin bends
4 Thick bends
5 DIL pads
6 Transistor pads
7 Dots + holes
8 0.1" edge cons
9 Mixture
Any sheet of above 35p

GRADE ONE GLASS PCB
Single Sided
178 240mm 1.50
420 195mm 1.95
420 245mm 2.95

DALO ETCH RESIST PEN
+ spare nib 90p

PHOTO SENSITIVE PCB
1st Class Epoxy Glass. For better results than spray mig. Expose to UV

Single sided
100 160 1.55
100 220 1.90
203 114 1.85
233 220 3.99
Double sided
100 160 1.65
100 220 2.15
203 114 2.21
233 220 4.55
Developer for above (do not use Sodium Hydroxide)/500ml 2.50

WIRE

Prices per Metre
Solid connecting wire 5p
Mains/Speaker Cable
Twin 1 amp 14p
Twin 2½ amp 16p
3 Core 2½ amp 18p
3 Core 6 amp 31p
3 Core 13 amp 56p
Screened Cable
Single 14p
Stereo 27p
Mini Single 12p
Mini Stereo 15p
4 Core 4 Screens 44p
4 Core 1 Screen 54p
8 Core 61p
12 Core 80p
Aerial Cable
50Ω RG58A 36p
75Ω UHF 36p
75Ω VHF 28p
300Ω Flat 14p
Rainbow Ribbon Cable
Prices per foot
8 Way 25p
10 Way 26p
16 Way 39p
20 Way 48p
24 Way 62p
30 Way 75p
32 Way 82p
40 Way 88p
64 Way 1.49

RECHARGE BATTERIES

Top quality. Don't throw these batteries away they change up to 1,000 times!
HP2 (1.2AH) 2.10
HP2 (4AH) 4.75
HP7 (½AH) 99p
HP11 (1.2AH) 2.29
PP3 4.95
Chargers
TYPE H
Adjustable to 6 of any HP type above £15.59
TYPE M
As above but charges 4AH batteries faster £25.95
TYPE P
PP3 £5.50
TYPE A
HP7 (Up to 4 at a time) £5.85

SOLDER

ANTEX SOLDERING IRONS
C240 (15W) 4.95
X S240 (25W) 6.25
Iron stand 1.75
C240 Element 2.25
XS240 Element 2.25
Bits C240
No. 2 (Small) 85p
No. 3 (Med) 85p
No. 6 (Micro) 85p
Bits XS240
No 50 (Small) 85p
No 51 (Med) 85p
No 52 (Long) 85p
SOLDER 125gms
18 swg 2.95
22 swg 3.10

PLUGS & SOCKETS

'D' Connectors 25 Way
Solder
Male 1.60
Female 2.09
PCB Wire Wrap
Male 1.60
Female 2.09
Covers £1.00
Phono Plugs
Blk, Red, Grn, Wht or Yellow 15p
Line Skts 15p
Chas Skt 1.20p
Dual 30p
Quad 40p

TRANSISTORS

A small sample of our vast stocks.

2N930	20p
2N930A	30p
2N1893	49p
2N2102	39p
2N2217	39p
2N2218	33p
2N2218A	25p
2N2219	27p
2N2219A	28p
2N2220	22p
2N2221	22p
2N2221A	23p
2N2222	24p
2N2222A	25p
2N2223	2.60
2N2223A	4.15
2N2368	25p
2N2369	19p
2N2369A	20p
2N2904A	27p
2N2905	28p
2N2905A	29p
2N2906	25p
2N2906A	30p
2N2907	25p
2N2907A	26p
2N2920	8.50
2N2923	25p
2N2924	15p
2N2925	15p
2N2926	10p
2N3053	27p
2N3054	56p
2N3055	60p
2N3055H	120p
2N3250	36p
2N3251	36p
2N3439	98p
2N3440	80p
2N3441	1.25
2N3442	1.35
2N3445	4.80
2N3446	6.09
2N3447	5.72
2N3448	6.56
2N3468	1.00
2N3553	1.06
2N3638	2.65
2N3638A	55p
2N3702	70p
2N3703	10p
2N3704	10p
2N3705	10p
2N3706	10p
2N3707	10p
2N3708	10p
2N3709	10p
2N3710	10p
2N3711	10p
2N3712	2.00
2N3713	1.98
2N3714	3.38
2N3715	3.31
2N3716	3.60
2N3773	1.99
2N3819	36p
2N3820	38p
2N3821	1.84
2N3822	90p
2N3823	45p
2N3824	1.70
2N3866	90p
2N3903	13p
2N3904	13p
2N3905	13p
2N3906	13p
2N4130	75p
2N4031	65p
2N4032	69p
2N4036	63p
2N4037	49p
2N4240	3.00
2N4347	2.26
2N4400	15p
2N4401	27p
2N4402	30p
2N4403	30p
2N4409	36p
2N4410	42p
2N4427	79p
2N4870	80p
2N4871	55p
2N4888	99p
2N4901	1.69
2N4902	1.85
2N4903	1.98
2N4904	2.15
2N4905	2.75
2N4906	2.99
2N4907	3.20
2N4908	3.15
2N3909	2.90
2N4918	65p
2N4919	75p
2N4920	85p
2N4921	95p
2N4922	69p
2N4923	99p
2N5086	36p
2N5087	39p
2N5088	37p
2N5089	37p
2N5190	68p
2N5191	70p
2N5193	90p
2N5194	79p
2N5245	37p
2N5246	40p
2N5247	45p
2N5248	46p
2N5249	48p
2N5266	2.88
2N5293	98p
2N5294	1.28
2N5295	1.37
2N5401	35p
2N5415	1.10
2N5416	1.54
2N5447	16p
2N5448	19p
2N5449	21p
2N5450	23p
2N5451	25p
2N5457	29p
2N5458	29p
2N5459	29p
2N5460	72p
2N5551	37p
2N5884	5.95
2N5886	5.95
2N6083	17.95
2N6121	57p
2N6122	59p
2N6123	65p
2N6124	59p
2N6125	65p
2N6126	75p
2N6129	79p
2N6130	93p
2N6131	98p
2N6132	83p
2N6133	1.14
2N6134	1.36
2N6253	1.45
2N6254	1.55
2SC1306	95p
2SC2078	1.52
2SJ49	3.50
2SJ50	3.75
2SJ82	4.29
2SK134	3.50
2SK135	3.75
2SK226	4.29
3N128	1.52
3N140	1.07
3N200	6.93
3N201	2.98
40360	60p
40361	67p
40362	67p
40363	2.95
40406	1.39
40407	75p
40408	1.58
40410	1.80
40411	2.85
40412	90p
40673	83p
40822	1.80
40871	79p
40872	79p
AC125	49p
AC126	32p
AC127	32p
AC128	35p
AC132	68p
AC141K	28p
AC142K	28p
AC151	51p
AC152	45p
AC153	55p
AC153K	64p
AC176	27p
AC176K	37p
AC187	25p
AC187K	28p
AC188	25p
AC188K	40p
AF239	55p
AF240	1.00
BC107	10p
BC107A	12p
BC107B	12p
BC108	10p
BC108A	12p
BC108B	12p
BC108C	14p
BC109	10p
BC109B	12p
BC109C	12p
BC140	29p
BC141	37p
BC142	29p
BC143	30p
BC147	10p
BC147A	10p
BC147B	10p
BC147C	20p
BC148	10p
BC148A	12p
BC148B	13p
BC148C	13p
BC149	10p
BC149B	12p
BC149C	13p
BC152	35p
BC153	23p
BC154	27p
BC157	11p
BC157A	12p
BC157B	13p
BC158	10p
BC158A	12p
BC158B	13p
BC159	11p
BC159A	12p
BC159B	13p
BC159C	18p
BC160	42p
BC161	48p
BC167	10p
BC167A	10p
BC167B	13p
BC168	10p
BC168B	15p
BC168C	10p
BC169	10p
BC169B	10p
BC169C	10p
BC177	16p
BC177A	25p
BC177B	26p
BC178	26p
BC178A	24p
BC178B	25p
BC179	20p
BC179A	25p
BC179B	25p
BC179C	27p
BC182	10p
BC182A	12p
BC182B	13p
BC182L	10p
BC182LA	13p
BC182LB	14p
BC183	10p
BC183A	11p
BC183B	12p
BC183C	13p
BC183L	10p
BC183LA	13p
BC183LB	13p
BC183LC	14p
BC184	10p
BC184B	12p
BC184C	13p
BC184L	10p
BC194LB	13p
BC184LC	14p
BC186	24p
BC187	24p
BC212	10p
BC212A	12p
BC212B	13p
BC212L	10p
BC212LA	13p
BC212LB	14p
BC213	11p
BC213A	11p
BC213B	12p
BC213C	13p
BC213L	10p
BC213LA	13p
BC213LB	13p
BC213LC	14p
BC214	10p
BC214B	12p
BC214C	13p
BC214L	10p
BC214LB	13p
BC214LC	14p
BC237	14p
BC237A	16p
BC237B	17p
BC237C	18p
BC238	14p
BC238A	15p
BC238B	16p
BC238C	17p
BC239	15p
BC239A	16p
BC239B	17p
BC239C	18p
BC300	45p
BC301	44p
BC302	43p
BC303	47p
BC327	14p
BC328	14p
BC337	15p
BC338	15p
BC440	32p
BC441	33p
BC460	32p
BC461	33p
BC516	40p
BC517	40p
BC547	13p
BC548B	15p
BC550B	16p
BC547A	14p
BC547B	14p
BC548	12p
BC548A	13p
BC548B	14p
BC548C	15p
BC549	13p
BC549B	14p
BC549C	15p
BC550	15p
BC550C	25p
BC557	15p
BC557A	16p
BC557B	16p
BC558	14p
BC558A	15p
BC558B	16p
BC558C	17p
BC559	15p
BC559B	16p
BC559C	17p
BC560	15p
BC560C	25p
BC650	45p
BC651	46p
BCY70	16p
BCY71	16p
BCY72	19p
BD131	44p
BD132	44p
BD135	40p
BD136	40p
BD137	42p
BD138	39p
BD139	39p
BD140	39p
BD237	98p
BD238	98p
BD239A	57p
BD239C	64p
BD240A	59p
BD240C	73p
BD241A	61p
BD241C	67p
BD242A	65p
BD242C	70p
BD243A	72p
BD243C	85p
BD244A	82p
BD244C	1.00
BD245A	1.14
BD245C	1.30
BD246A	1.20
BD246C	1.50
BD249A	2.00
BD249C	2.31
BD250A	2.11
BD250C	2.46
CD419	1.29
BD420	1.37
BD437	88p
BD438	88p
BD439	90p
BD440	91p
BD441	91p
BD442	93p
BD529	1.20
BD530	1.30
BD535	75p
BD536	75p
BD537	80p
BD538	80p
BD539	80p
BD539C	1.10
BD540	85p
BD540C	1.20
BD675	72p
BD676	77p
BD677	78p
BD678	83p
BD711	1.32
BD712	1.32
BDX32	3.47
BDX66B	5.95
BDX67B	5.95
BDY54	1.70
BDY55	1.75
BDY56	1.80
BDY57	5.25
BDY58	6.15
BF194	12p
BF195	12p
BF196	12p
BF197	12p
BF198	15p
BF199	15p
BF200	14p
BF224J	32p
BF225J	35p
BF244A	35p
BF244B	39p
BF245A	30p
BF245B	51p
BF246	52p
BF246A	59p
BF246B	53p
BF247A	54p
BF247B	55p
BF254	39p
BF255	42p
BF256A	35p
BF256B	48p
BF256C	62p
BF257	30p
BF258	32p
BF259	35p
BF457	46p
BF458	58p
BF468	65p
BF469	86p
BF470	86p
BFR39	22p
BFR40	22p
BFR41	22p
BFR79	22p
BFR80	22p
BFR81	22p
BFR90	2.11
BFS28	2.95
BFS61	1.00
BFS98	1.10
BFX29	26p
BFX30	27p
BFX50	23p
BFY51	23p
BFY52	23p
BFY53	31p
BSX19	24p
BSX20	24p
BSX21	40p
BU104	2.22
BU105	1.70
BU108	3.95
BU109	3.29
BU126	1.47
BU204	2.25
BU205	1.75
BU206	1.90
BU208	1.98
BU226	3.95
BU326S	2.35
BU406	1.45
BU407	1.45
BU408	1.35
BU500	2.95
BUY18S	3.95

DIODES

1N34A	30p
1N821	70p
1N823	92p
1N914	4p
1N916	6p
1N4001	4p
1N4002	4½p
1N4003	5p
1N4004	5½p
1N4005	6p
1N4006	6½p
1N4007	7p
1N4009	20p
1N4148	3p
1N4150	18p
1N4448	22p
1N5400	12p
1N5401	13p
1N5402	14p
1N5403	15p
1N5404	18p
1N5406	18p
1N5407	19p
1N5408	20p
1N5024	52p
1S44	10p
BA102	25p
BA115	25p
BA133	40p
BA138	30p
BA142	20p
BA155	15p
BA156	38p
BA157	25p
BA158	30p
BA159	32p
BA182	40p
BA201	18p
BA202	26p
BA316	25p
BA317	25p
BA318	30p
BAV10	16p
BAV19	15p
BAV20	15p
BAX13	10p
BB109G	65p
BY126	20p
BY127	22p
BY134	52p

JUST RELEASED
NEW ILLUSTRATED CATALOGUE
£1.00 inc.VAT, p&p

SCR's, TRIACS DIACS

THYRISTORS
4, 8 & 12 Amps Texas TO220
Suffice A 100V
B 200V
C 300V
D 400V
M 600V

TIC106A	46p
TIC106B	47p
TIC106C	48p
4A TIC106D	49p
TIC106M	68p
TIC116A	66p
TIC116B	68p
8A TIC116C	71p
TIC116D	73p
TIC116M	80p
TIC126A	72p
TIC126B	72p
2A TIC126C	73p
TIC126D	77p
TIC126M	96p

TRIACS
Texas 400V
TO220 Case

TIC206D(4A)	66p
TIC225D(6A)	74p
TIC226D(8A)	88p
TIC236D(12A)	1.16
TIC246D(16A)	1.22
TIC253D(20A)	1.90
TIC263D(25A)	2.11

DIACS

BR100	25p
ST2	25p

ZENER'S

400 500mW E24 Series
2.4-47V 7p
1.3 Watt E24 Series
3.3-82V 14p

BRIDGE

(PIV shown in brackets) 1½ amp type

W01 (100)	20p
W02 (200)	26p
W04 (400)	28p
W08 (800)	40p

2 amp type Square with hole

S01 (100)	37p
S02 (200)	40p
S04 (400)	40p
S08 (800)	55p

6 amp type Square with hole

PW01 (100)	50p
PW02 (200)	78p
PW04 (400)	85p
PW06 (600)	90p

25 amp type Metal clad with hole

K01 (100)	2.20
K02 (200)	2.30
K04 (400)	2.80
K06 (600)	3.40
BY W64	3.95
35A 400V	3.95

OPTO

LEDs
R Red
G Green
Y Yellow
Large diffused

	1	50
R5D	9p	7p
G5D	15p	12p
Y5D	15p	12p

Small diffused

R2D	8p	6p
G2D	12p	10p
Y2D	12p	10p

Micro 0.1"

R1D	25p	22p
G1D	27p	25p
Y1D	27p	25p

Large clear

R5C	12p	10p
G5C	17p	13p
Y5C	17p	13p

Super bright high efficiency
Large (100 times brighter)

R5U	38p	29p
G5U	42p	34p
Y5U	42p	34p

Rectangular
Stackables LEDs

R6L	17p
G6L	18p
Y6L	19p

LINICS

AY1-5050	95p
AY3-8910	3.66
AY3-8912	4.40
CA3048	2.15
CA3059	2.80
CA3090AQ	3.70
CA3130E	87p
CA3130T	1.80
CA3140E	39p
CA3140T	95p
HA1366W	2.40
HA1388	2.54
ICL7106	6.85
ICL7107	9.50
ICL7611	97p
ICL8038	2.95
ICL7555	80p
ICL7556	1.50
LC7120	3.20
LC7130	3.20
LC7137	3.95
LF347	1.50
LF351	47p
LF353	92p
LF355	83p
LF356	92p
LF357	1.09
LF398	4.59
LM335Z	1.19
LM348N	62p
LM349N	1.09
LM350K	4.60
LM379S	4.50
LM380N14	75p
LM380N8	1.50
LM381AN	2.26
LM381N	1.40
LM382N	1.12
LM383T	3.40
LM384N	1.40
LM386	88p
LM388N	2.43
LM391N60	1.70
LM391N80	1.93
LM723CH	95p
LM723CN	35p
LM725CH	3.40
LM725CN	3.19
LM741CH	96p
LM741CN	15p
LM747CN	69p
LM748CH	1.00
LM748CN	35p
LM1871	3.25
LM1872	4.38
LM1886	7.44
LM1889	3.77
LM2907N	2.75
LM2907N8	2.60
LM2917N	1.89
LM2917N8	1.89
LM387N8	1.65
LM3900	49p
LM3911	1.20
LM3914	2.50
LM3915	2.50
LM3916	2.50
LM13600	95p
MF10	3.50
OM335	7.20
NE531N	1.36
NE543N	2.50
NE544N	1.95
NE555	16p
NE556	45p
NE558	1.89
NE560	3.25
NE565	1.18
NE566	1.49
NE567	1.37
NE570	4.07
NE571	3.99
NE5534A	95p
RC4136	59p
TBA500	2.97
TBA500Q	3.11
TBA510	2.95
TBA510Q	3.05
TBA520	2.57
TBA520Q	2.75
TBA530	2.55
TBA530Q	2.76
TBA540	2.72
TBA540Q	2.74
TBA550	2.25
TBA550Q	3.27
TBA560C	2.87
TBA570	2.37
TBA570Q	2.48
TDA1002	3.39
TDA1003	3.94
TDA1004	2.87
TDA1005	3.94
TDA1010A	2.25
TDA1022	4.95
TDA2611A	2.50
TL061	40p
TL062	60p
TL064	99p
TL071	25p
TL072	50p
TL074	99p
TL081	25p
TL082	50p
TL084	89p
UAA170	1.69
UAA180	1.69
ULN2003	85p
UPC575C2	2.50
UPC1156	2.75
XR2206	2.92
ZN414	1.00
ZN419	2.25
ZN1034	1.99

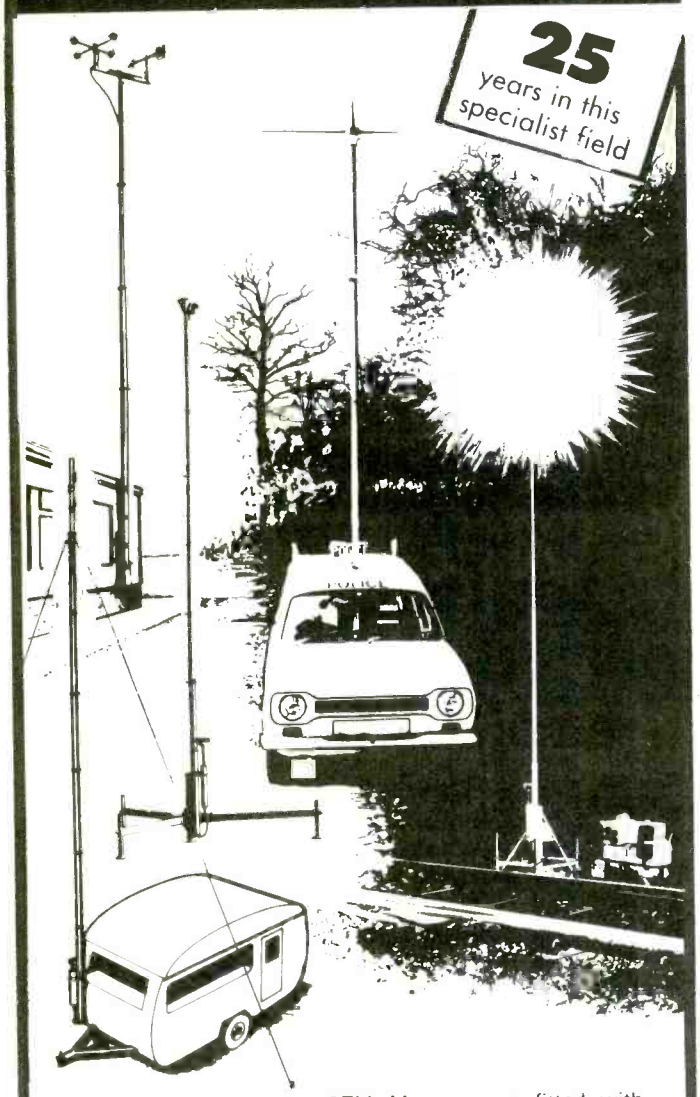
74TTL

7400	16p
7401	16p
7402	16p
7403	16p
7404	16p
7405	16p
7408	14p
7409	14p
7410	15p
7411	16p
7412	18p
7413	18p
7414	25p
7416	19p
7417	19p
7420	15p
7421	19p
7422	19p
7423	19p
7425	19p
7426	19p
7427	19p
7428	26p
7430	14p
7432	22p
7433	22p
7437	25p
7438	21p
7440	15p
7441	55p
7442	32p
7443	89p
7444	89p
7445	49p
7446	59p
7447	39p
7448	49p
7450	15p
7451	15p
7453	15p
7454	14p
7460	15p
7470	34p
7472	25p
7473	25p
7474	19p
7475	25p
7476	25p
7480	39p
7481	1.19
7482	63p
7483	38p
7484	69p
7485	60p
7486	19p
7489	1.68
7490	20p
7491	35p
7492	25p
7493	25p
7494	36p
7495	36p
7496	35p
7497	89p
74100	80p
74104	50p
74105	55p
74107	19p
74109	25p
74110	35p
74116	50p
74118	55p
74119	59p
74120	59p
74121	25p
74122	35p
74123	35p
74125	30p
74126	29p
74128	35p
74132	29p
74136	27p
74141	55p
74142	1.75
74143	1.95
74144	1.95
74145	38p
74147	89p
74148	55p
74150	49p
74151	35p
74153	35p
74154	49p
74155	40p
74156	39p
74157	29p
74159	75p
74160	59p
74161	48p
74162	39p
74163	39p
74164	39p
74165	39p
74166	48p
74170	1.25
74172	2.50
74173	59p
74174	54p
74175	49p
74176	39p
74177	45p
74178	79p
74180	40p
74181	1.15
74182	60p
74184	89p
74185	89p
74186	4.69
74188	2.50
74190	48p
74191	48p
74192	45p
74193	45p
74194	40p
74195	40p
74196	45p
74197	39p
74198	79p
74199	83p
74221	53p

74LS TTL

74LS00	15p
74LS01	15p
74LS02	15p
74LS03	15p
74LS04	15p
74LS05	15p
74LS08	15p
74LS10	15p
74LS11	15p
74LS12	15p
74LS13	15p
74LS14	24p
74LS15	15p
74LS20	15p
74LS21	15p
74LS22	15p
74LS27	15p
74LS28	15p
74LS30	15p
74LS32	15p
74LS33	15p
74LS37	15p
74LS38	15p
74LS40	15p
74LS42	28p
74LS47	35p
74LS51	14p
74LS54	14p
74LS55	14p
74LS73	18p
74LS74	18p
74LS75	18p
74LS76	19p
74LS78	19p
74LS83	36p
74LS85	41p
74LS86	16p
74LS90	24p
74LS92	29p
74LS93	24p
74LS95	39p
74LS96	93p
74LS107	35p
74LS109	23p
74LS112	22p
74LS113	19p
74LS114	22p
74LS122	32p
74LS123	36p
74LS124	89p
74LS125	24p
74LS126	25p
73LS132	29p
74LS136	24p
74LS138	24p
74LS139	28p
74LS145	69p
74LS147	99p
74LS148	75p
74LS151	37p
74LS153	39p
74LS154	79p
74LS155	29p
74LS156	36p

The lightweight mast with 101 applications



The smoothly operated QTM Mast comes fitted with handpump or can be vehicle mounted with 'Power Pack' for extension and retraction. Available in a range of heights up to 15 metres, the QTM mast can provide the ideal answer for:

- Mobile Radio Telephone
- Police Mobile HQ (UHF)
- Field Telecommunications
- Floodlighting
- Anemometer and Wind Measurement
- Environmental - gas sampling collector
- High level photography
- Meteorology
- And a host of other uses

CLARK MASTS

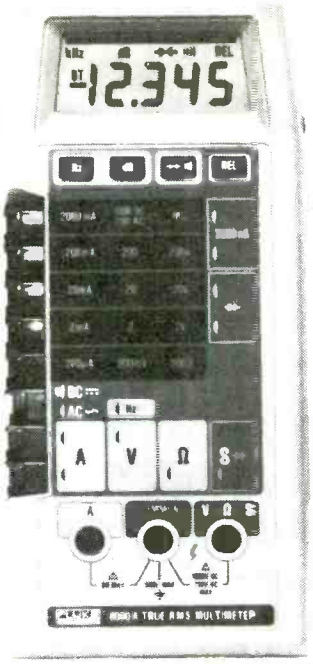
Find out more about the QTM series by writing or phoning:-

U.K.
CLARK MASTS LTD.(W.W.)
Evergreen House, Ringwood Road,
Binstead, Isle of Wight,
England PO33 3PA
Tel: Isle of Wight (0983) 63691
Telex 86686

EUROPE
GENK TECHNICAL PRODUCTS N.V.(W.W.)
Woudstraat 21, 3600 Genk.
Belgium
Telefoon 011-380831
Telex 39354 Genant B

WW – 011 FOR FURTHER DETAILS

"Instruments for Industry"



FLUKE®

Multimeters EX-STOCK from ANDERS

This superb range of hand-held and bench multimeters offers a unique choice of 3½ or 4½ digit specifications and features. Engineering excellence at competitive prices with numerous supporting accessories to suit design, production and service needs. Now available ex-stock from one of the U.K.'s most experienced electrical measurement specialists. The complete range of Anders instruments and panel meters is described in the "Instruments for Industry" catalogue.

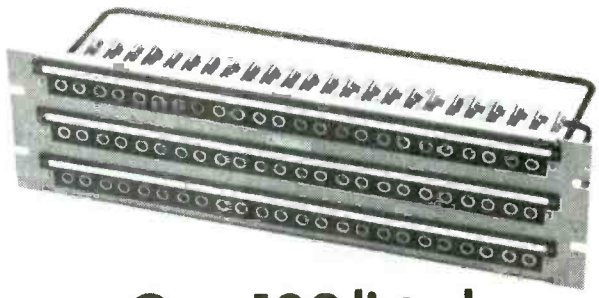
For your personal copy contact:

ANDERS

ANDERS ELECTRONICS LIMITED
48-56 Bayham Place
London NW1 0EU
Tel: 01-387 9092. Telex: 27364

WW – 024 FOR FURTHER DETAILS

Audio Jackfields?



Over 100 listed in our Catalogue.

Write or call for your free copy.

FFD FUTURE FILM DEVELOPMENTS
114 Wardour Street, London W1V 3LP. Telephone: 01-434 3344.
Telex: 21624 ALOFFD G. Cables: Allotrope-London W1.

WW – 065 FOR FURTHER DETAILS

www.americanradiohistory.com

IRVINE BUSINESS SYSTEMS LTD.

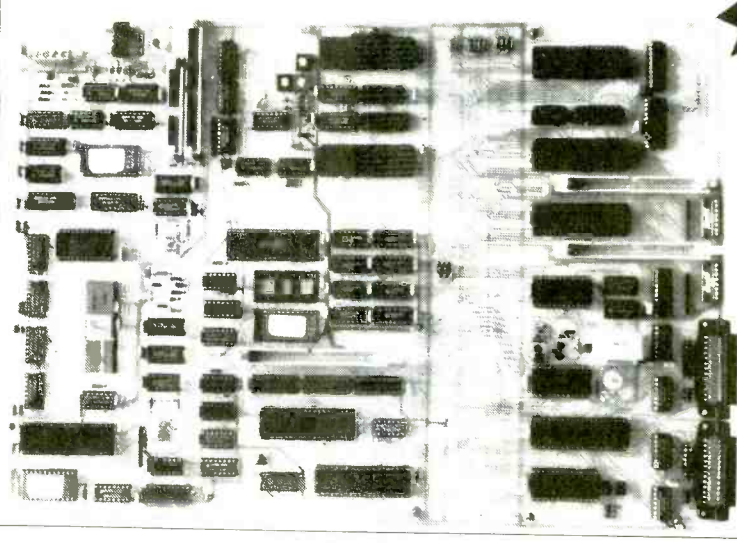
KEYBOARDS FROM **£95.00**
12'' P31 MONITORS
FROM **£95.00**

CP/M 2-2 FOR
IBS 750 **£95.00**
DOCS **£15.00**

5¼'' TEAC DISK DRIVES
250K FD55A = **£159.00**
500K FD55E = **£189.00**
IMB FD55F = **£249.00**
Subject to Yen fluctuation

SWITCH MODE POWER SUPPLY
+ 5V @ 7 amps
+12V @ 3 amps
+12V @ 1 amp
− 5V @ 1 amp
80w
£79.95

A SINGLE CARD COMPUTER FOR ONLY
THE **IBS 750** S.B.C.



£423.35
+ V.A.T.
Deposit **£48** Per Month **£19**

- ★ 4 MEG Z80 CPU
- ★ 64K RAM
- ★ 16K PROM
- ★ 5'' & 8'' DISK CONTROLLER
- ★ 80×24 VIDEO GEN
- ★ 2×SERIAL I/O
- ★ 4×PARALLEL I/O
- ★ IEEE 488 INTERFACE
- ★ KEYBOARD PORT
- ★ HARDWARE RTC
- ★ MONITOR IN PROM
- ★ BARE BOARD AVAILABLE @ **£99.95**

NEW BUDGET ACCOUNT
£1,000 INSTANT CREDIT
ON ANY PRODUCTS

IRVINE BUSINESS SYSTEMS LTD
1 Montgomery Place
Irvine, Ayreshire KA12 8NP

10% Deposit + 24 × Monthly Payment Credit Limit. A.P.R. 30.6%

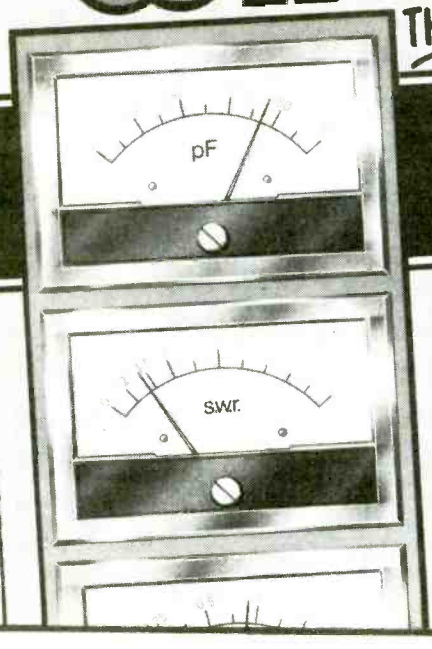
MADE IN IRVINE SCOTLAND BY IRVINE BUSINESS SYSTEMS LTD.

OCTOBER 1983 90p

Practical Wireless
THE RADIO MAGAZINE

Five projects for the radio enthusiast

TEST GEAR SPECIAL



- **Sensitive Capacitance Meter**
- **QRP RF Wattmeter**
- **Digital Calibrator**
- **Simple wavemeter for 144MHz**
- **QRP SWR Bridge**

Separate designs to test small capacitors, measure low power transmitter output and antenna SWR. Check 144MHz transmitters and produce frequency markers to VHF and beyond.
AND **RIG REVIEWS**
ICOM IC-505 50MHz
PLUS the STANDARD matching VHF & UHF mobile rigs
OCTOBER ISSUE 90p
ON SALE NOW

www.americanradiohistory.com

VISIT OR 'PHONE
OPEN 6 DAYS A WEEK
ALL STOCK ON DISPLAY

HENRY'S AUDIO ELECTRONICS

All Prices include VAT
Export or VAT exclusive prices available.

COMPUTERS • COMMUNICATIONS • TEST EQUIPMENT • COMPONENTS

THERMAL • MATRIX • LINE PRINTER

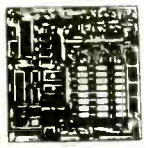
150 to 180 LPM • Full 96 CH ASCII • 40 CPL • 280 Dots P/L • Auto-underline • 50 Graphic Symbols • Back Space • Self Test • VU/HOR TABS • 7 x 10 Matrix • 4.4" Wide Paper • Bidirectional • 220/240V AC • Size Approx. 9.8 x 2.8 x 7.2". SUITABLE FOR: TANDY • BBC • ORIC • NASCOM • GEMINI • ACORN • NEW BRAIN • DRAGON • etc. etc. (Your enquiries invited).
Complete with 3 rolls paper.
(Interface unit with leads £15 – state model).
List price approx £187 with paper. (UK C/P £1.05) **£129.95** inc. V.A.T.

SAVE £57

SANYO DM2112 HIGH RESOLUTION MONITOR

12" green display: Composite video: 1280 characters: Over 15 MHZ B/W: 240V AC 34 w: 16" x 11¼" x 12⅝": Alphanumeric and Graphic display:
Usually £89.95 - £99.95 Price **£69.95** incl VAT (UK C/P & ins £2.05)

SAVE £20 TO £30

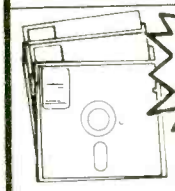


PROFESSIONAL SERIES COMPUTERS IN STOCK

GEMINI • GALAXY • NASCOM • 80-Bus multiboards. Complete and part systems to suit your needs. Frames, boards, power supplies, keyboards, disc systems, etc. FOR THE PROFESSIONAL USER – SEND FOR DETAILS

DELUXE 69 KEY ASCII KEYBOARD

General purpose, steel plate, output, redefinable, +5 and 12 volt, neg. strobe pulse, 4 user definable keys, Shift and control keys, etc. **£42.95** inc. VAT. (UK C/P 85p)
ALSO Type 756A £51. Type 771 £66. Inc. VAT



3 NEW SOFTWARE PRODUCTS

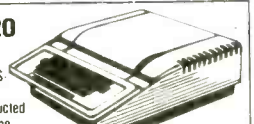
MDIS (C) INTELLIGENT DISASSEMBLER. For all CP/M based machines. **£57.50** inc. VAT

IVC HI-RES (C) For Gemini and others (please enquire) provides pseudo high resolution graphics. **£17.25** inc. VAT

DISKPEN (C) Version 3. Lost cost word processor. For Gemini and others (please enquire) **£51.75** inc. VAT

PLUS range of overlays available.
Send for details of all above.
(C) Copyright Cubegate Ltd. 1983. All rights reserved)

I.T.T. 2020 CABINET



Complete PROFESSIONAL Case beautifully constructed with cut out for one 'CHERRY' keyboard, plus ample room to house a COMPLETE SYSTEM and power supply. Complete with fittings (Case top detachable). Unit is silver-grey in colour. Robust construction. Sloping front with side ventilation. Ideal for NASCOM, ACORN, TANGERINE or your own system. Size 18" x 15" x 4" (front slopes)
£27.50 inc. VAT (UK C/P £2.50)

'CHERRY' ADD-ON KEYPAD

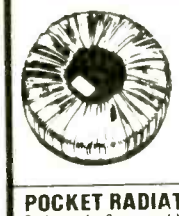
QUANTITIES AVAILABLE FROM STOCK

A compact 16 button keypad suitable for use with Cherry keyboard to extend its functions. Supplied brand new with data. A 4 x 4 non-encoded single mode keyboard
£5.95 inc. VAT (UK C/P Free)

COMPUTER POWER SUPPLY

Switched mode, stabilised, self protecting, S/C protected, etc. 220/240 V AC. -5V 3.3A +12V 2.4A 40% cycle. -5V 0.5A. 12V 0.5A. Suitable Apple replacement
£57.50 inc. VAT (UK C/P £1.50)

SELECTION OF SPECIAL OFFERS – QUANTITIES AVAILABLE (Inc. VAT)



TOROIDAL TRANSFORMER

100 watts isolation
230/240 V AC plus 8-0-8V 4A 15-0-15V 0.645A 30V 0.16A
Size approx 4" dia. x 1½"
£7.95 (UK C/P 75p)

RADIO INTERFERENCE FREE

24 hr 230/240V AC digital clock movements with alarm by Braun **£4.50** (UK C/P 50p)

CENTAUR FANS

CU7983 115V 50/60HZ 12/13W Impedance protected (use 2 in series for 230V) 4" x 4" x 1". Two for **£10.00** (UK C/P 70p)

POCKET RADIATION DETECTORS

Dosimeter for Gamma and X-Rays. 0-5r.
£6.95

ASTEC UHF MODULATORS

UM1233 cased for computers etc. **£3.50** (UK C/P 40p)
ALSO STOCKED – LARGE RANGES All semiconductors, valves, relays and other components. Plus millions of Res. Caps. presets, pots, etc. etc. for bulk and export users

CASSETTE MECHANISMS

Fitted counter, motor, record and erase heads, solenoid etc. Brand new available 6V DC or 12V DC (state which) **£5.95** (UK C/P 65p)

ULTRASONIC TRANSDUCERS

with cables, 40 KHZ £2.95 per pair (UK C/P 40p)

MULLARD MODULES (UK C/P 65p per 1-3)

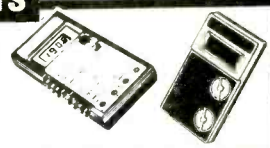
LP1171 IF and LP1179 AM/FM Tuner pr £5.75
LP1186 Varicap Tuner £5.00
LP1157 AM Tuner £2.50

TOROIDAL POWER SUPPLY

12V and 5V 1 amp max stabilised 6" x 2" x 1". £5.95 (UK C/P 65p)

ALL ABOVE AVAILABLE BY POST OR FOR CALLERS TO HENRY'S

ALL MODELS 3½ DIGIT UNLESS STATED



DIGITAL MULTIMETERS

(UK C/P FREE)
All models 3½ digit unless stated.

HAND HELD
KD25C■ 13 range 0.2A DC 2 meg ohm £23.50
KD305■ 16 range 10A DC 2 meg ohm £26.95
KD30C■ 26 range 1A AC/DC 20 meg ohm £29.50
KD55C■ 28 range 10A AC/DC 20 meg ohm £33.50
6010* 28 range 10A AC/DC 20 meg ohm £34.40
7030* As 6010 but 0.1% basic £41.30
KD615■ 16 range 10A DC 2 meg plus Hfe tester £39.95
189M 30 range 10A AC/DC 20 meg plus Hfe tester £69.95
DM2350■ 21 range 10A AC/DC 20 meg ohm miniature hand held auto range £49.95
■ Free carry case (rotary controls)
* Carry case £2.95 (side buttons)
Beckman T100 34 range 10A AC/DC 20 meg ohm £56.35
Beckman T110 As T100 plus Cont. test etc. £67.85
Sifam 2200B 21 range 2A AC/DC 20 meg ohm SPECIAL OFFER £29.95
Metrix (ITT) professional 3½ + 4½ digit hand held DMM's standard and true RMS. 4 models stocked £77.00 - £201.25

BENCH MODELS
TM356• 27 range LCD 2A AC/DC 20 meg £97.75
TM355• 29 range LED 10A AC/DC 20 meg £86.25
TM351• 29 range LCD 10A AC/DC 20 meg £120.75
• Optional carry case £6.84
2001 28 range LCD 10A AC/DC plus 5 range cap. Meter with case £108.00
TM451 4½ digit LCD every facility (0.02%) £171.00
1503a 4½ digit LCD every facility (0.05%) £171.00
1503Ha 0.03% basic version of above £189.00
1504 True RMS version £201.25
Sifam 2500 24 range LCD 2A AC/DC 20 meg SPECIAL OFFER £79.95

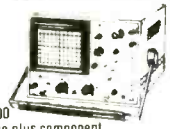
FREQUENCY COUNTERS

PFM200A 200 MHZ hand held pocket 8 digit LED £77.60
MET100 8 digit LED bench 2 ranges 100 MHZ £102.35
MET600 8 digit LED bench 3 ranges 600 MHZ £132.25
MET1000 8 digit LED 3 ranges 1 GHZ £182.85
TF040■ 8 digit LCD 40 MHZ £126.50
TF200■ 8 digit LCD 200 MHZ £166.75
■ Optional carry case £6.84
Probe kits x1 £7.95, x10 £9.45, x1-x10 £10.50
Prescalers – Extended range of most counters
TP600 600 MHZ £43.00
TP1000 1 GHZ £74.00

ELECTRONIC INSULATION TESTER

YF501 500V/0-100m with carry case £63.00

OSCILLOSCOPES



Full specification any model on request. SAE by post.
'HM' Series HAMEG: 'SC' THANDAR: 'CS' TRIO: '3' CROTECH 'V' HITACHI
SINGLE TRACE UK C/P £3.00
3030 15 MHZ 5mV. 95mm tube plus component tester C/P £3.00 £177.10
SC110A Miniature 10 MHZ battery portable Post free £171.00
Optional carry case £6.84 AC adaptor £6.69
Nicads £12.50 DUAL TRACE (UK C/P £4.00)
HM103 15MHZ 2mV. 6 x 7 display plus component tester C/P £3.00 £181.70
HM203/4 Dual 20 MHZ plus component tester £303.60
CS1562A Dual 10 MHz (List £321.00) £269.50
3131 Dual 15 MHZ + component tester £276.00
CS1566A Dual 20 MHZ All facilities (List £401.35) £349.50
HM204 Dual 20 MHZ plus component tester sweep delay £419.75
HM705 Dual 70 MHZ sweep delay £676.00
V212 Dual 20 MHZ £399.25•
V222 Dual 20 MHZ plus extra facilities £391.00•
V422 Dual 40 MHZ portable £586.50•
V203F Dual Trace 20 MHZ sweep delay £408.25•
V134 Dual Trace 10 MHZ storage 1092.50•
All HITACHI, CROTECH & TRIO MODELS AVAILABLE
OPTIONAL PROBE KITS • With probes
X1 £7.95 X10 £9.45 X1 - X10 £10.50

AC CLAMPMETER

ST300 0/300A 0/600 V AC 0/1 Kohm 9 ranges With carry case (UK C/P 65p) £28.50

SIGNAL GENERATORS

(220/240V AC)
FUNCTION: All sine/square/triangle/TTL etc.
TG100 1HZ-100 KHZ £90.00
TG101 1HZ-200 KHZ £113.85
TG102 0.2HZ-2 MHZ £166.75
PULSE
TG105 Various facilities 5 HZ-5 MHZ £97.75
AUDIO: Multiband Sine/Square
LAG27 10 HZ to 1 MHZ £90.85
AG202A 20 HZ to 200 KHZ (list £94.50) £83.50
LAG 120A 10 HZ-1MHZ Low Distortion £159.85
RF
SG402 100 KHZ to 30 MHZ (list £79.50) £69.50
LSG17 100 KHZ to 150 MHZ £79.35

MULTIMETERS (UK C/P 65p)

HM102BZ 20K/V 10A DC 22 range & cont. buzzer £13.50
C7081 50 K/V Range Doubler 10A DC Total 36 Ranges SPECIAL OFFER £12.50
TMK500 23 ranges 30K/V 12A DC plus cont. buzzer £23.95
NH56R 20K/V. 22 range pocket £10.95
830A 26 range 30K/V. 10A AC/DC overload protection, etc £23.95
360TR 23 range 100 K/V. Large scale 10A AC/DC plus Hfe £39.95
AT2100 10A AC/DC 31 range 100 K/V deluxe £33.50
AT1020 18 range 20K/V. Deluxe plus Hfe tester £18.95
YN360TR 19 range 20K/V plus Hfe tester £15.95
Metrix Professional multimeters in stock 3 models from £74.75

VARIABLE POWER SUPPLIES (UK C/P £1.00)

PP241 0/12/24V 0/1A £35.00
PP243 3 amp version £59.95
230N 0/30V 1A Twin meter £99.50

LOGIC PROBES

LP10 10 MHZ £28.50
DLP50 50 MHZ with carry case and accessories £49.95

HIGH VOLTAGE METERS

Direct reading 0/40 KV 20K/Volt £23.00 (UK C/P 65p)
Also 0/30, 0/45KV version £39.95

DIGITAL CAPACITANCE METER

0.1 pf to 2000 mfd LCD 8 ranges DM6013 £52.75

RETAIL • MAIL ORDER • EXPORT • INDUSTRIAL • EDUCATIONAL
Company, College Dept. etc. Official Orders Welcome – (Subject to approval)

Cubegate Ltd

HENRY'S 404-406 Edgware Road, London, W2 1ED
Computers 01-402 6822 · Equipment 01-724 0323 · Components 01-723 1008

AUDIO ELECTRONICS 301 Edgware Road, London, W2 1BN
01-724 3564 (All post to 301 Edgware Road, London, W2 1BN)

ORDER BY PHONE OR BY POST OR CALL IN AND SEE FOR YOURSELF

BARCLAYCARD VISA · VISA · AMERICAN EXPRESS

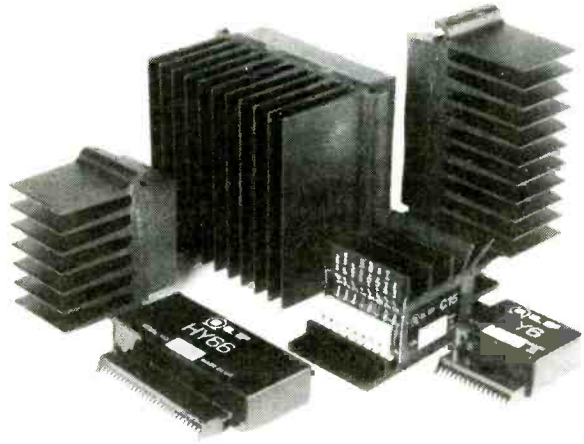
FREE CATALOGUES

Please state type required. Send large S.A.E. (20p UK)
Test Equipment
Computers
Audio Communications
Components
Schools, Colleges, Companies
Export Free on Written Request

WW – 047 FOR FURTHER DETAILS

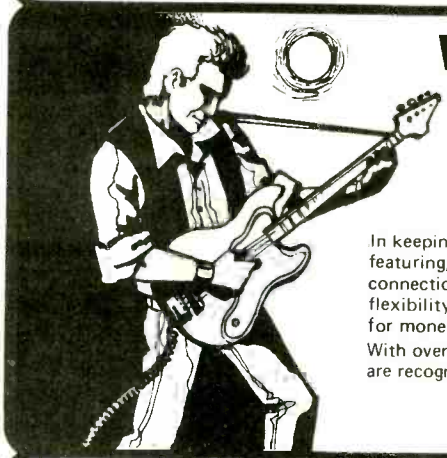
www.americanradiohistory.com

AMPLIFIERS



Over the last few years we have received feedback via the general public and industry that our products are from Taiwan, Singapore, Japan, etc... ILP are one of the few 'All British' electronics Companies manufacturing their own products in the United Kingdom. We have proved that we can compete in the world market during the past 12 years and currently export in excess of 60% of our production to over twenty different countries – including USA, Australia and Hong Kong. At the same time we are able to invest in research and development for the future, assuring security for the personnel, directly and indirectly, employed within the UK. We feel very proud of all this and hope you can reap some of our success.

I.L.Potts – Chairman



WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/µs. Risetime: 5µs. S/N ratio: 100db.
Frequency response (–3dB) 15Hz – 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω. Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp.
A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations.
Please send for details.

Mounting Boards
For ease of construction we recommend the **B6** for modules HY6–HY13 £1.05 (inc. VAT) and the **B66** for modules HY66–HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£39.44
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	800	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£49.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/µs. Rise time: 3µs. S/N ratio: 100db
Frequency response (–3dB): 15Hz – 100KHz. Input sensitivity: 500mV rms
Input impedance: 100K Ω. Damping factor: 100Hz >400.

'NEW to ILP' In Car Entertainments

C15
Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction.

£9.14 (inc. VAT)

Mounts anywhere in car.

Automatic switch on.

Output power maximum 22w peak into 4Ω
Frequency response (–3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm. Weight 256 gms.

C1515
Stereo version of C15.

£17.19 (inc. VAT)

Size 95 x 40 x 80. Weight 410 gms.

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "0" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

www.americanradiohistory.com

TOROIDALS

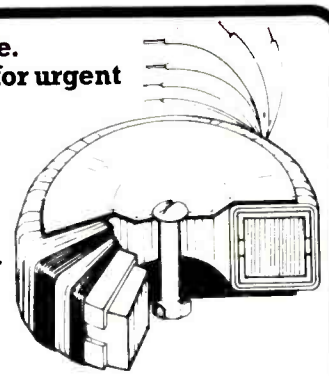
The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidals offer in size, weight, lower radiated field and, thanks to I.L.P., PRICE.

Our large standard range is complemented by our SPECIAL DESIGN section which can offer a prototype service within 7 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.

***Gold service available. 21 days manufacture for urgent deliveries.**

***Orders despatched within 7 days of receipt for single or small quantity orders.**

***5 year no quibble guarantee.**



TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
15 VA 62 x 34mm 0.35Kg Regulation 19%	0x010	6+6	1.25	**£5.12** + p&p £0.78 + VAT £0.89 TOTAL £6.79
	0x011	9+9	0.83	
	0x012	12+12	0.63	
	0x013	15+15	0.50	
	0x014	18+18	0.42	
	0x015	22+22	0.34	
	0x016	25+25	0.30	
	0x017	30+30	0.25	
(encased in ABS plastic)				
30 VA 70 x 30mm 0.45Kg Regulation 18%	1x010	6+6	2.50	**£5.49** + p&p £1.10 + VAT £0.99 TOTAL £7.58
	1x011	9+9	1.66	
	1x012	12+12	1.25	
	1x013	15+15	1.00	
	1x014	18+18	0.83	
	1x015	22+22	0.68	
	1x016	25+25	0.60	
	1x017	30+30	0.50	
50 VA 80 x 35mm 0.9Kg Regulation 13%	2x010	6+6	4.16	**£6.13** + p&p £1.35 + VAT £1.12 TOTAL £8.60
	2x011	9+9	2.77	
	2x012	12+12	2.08	
	2x013	15+15	1.66	
	2x014	18+18	1.38	
	2x015	22+22	1.13	
	2x016	25+25	1.00	
	2x017	30+30	0.83	
	2x028	110	0.45	
	2x029	220	0.22	
	2x030	240	0.20	
80 VA 90 x 30mm 1Kg Regulation 12%	3x010	6+6	6.64	**£6.66** + p&p £1.72 + VAT £1.26 TOTAL £9.64
	3x011	9+9	4.44	
	3x012	12+12	3.33	
	3x013	15+15	2.66	
	3x014	18+18	2.22	
	3x015	22+22	1.81	
	3x016	25+25	1.60	
	3x017	30+30	1.33	
	3x028	110	0.72	
	3x029	220	0.36	
	3x030	240	0.33	

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
120 VA 90 x 40mm 1.2Kg Regulation 11%	4x010	6+6	10.00	**£7.42** + p&p £1.72 + VAT £1.37 TOTAL £10.51
	4x011	9+9	6.66	
	4x012	12+12	5.00	
	4x013	15+15	4.00	
	4x014	18+18	3.33	
	4x015	22+22	2.72	
	4x016	25+25	2.40	
	4x017	30+30	2.00	
	4x018	35+35	1.71	
	4x028	110	1.09	
	4x029	220	0.54	
	4x030	240	0.50	
160 VA 110 x 40mm 1.8Kg Regulation 8%	5x011	9+9	8.89	**£8.43** + p&p £1.72 + VAT £1.52 TOTAL £11.67
	5x012	12+12	6.66	
	5x013	15+15	5.33	
	5x014	18+18	4.44	
	5x015	22+22	3.63	
	5x016	25+25	3.20	
	5x017	30+30	2.66	
	5x018	35+35	2.28	
	5x026	40+40	2.00	
	5x028	110	1.45	
	5x029	220	0.72	
	5x030	240	0.66	
225 VA 110 x 45mm 2.2Kg Regulation 7%	6x012	12+12	9.38	**£9.81** + p&p £2.05 + VAT £1.78 TOTAL £13.64
	6x013	15+15	7.50	
	6x014	18+18	6.25	
	6x015	22+22	5.11	
	6x016	25+25	4.50	
	6x017	30+30	3.75	
	6x018	35+35	3.21	
	6x026	40+40	2.81	
	6x025	45+45	2.50	
	6x033	50+50	2.25	
	6x028	110	2.04	
	6x029	220	1.02	
	6x030	240	0.93	

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
300 VA 110 x 50mm 2.6Kg Regulation 6%	7x013	15+15	10.00	**£10.88** + p&p £2.05 + VAT £1.94 TOTAL £14.87
	7x014	18+18	8.33	
	7x015	22+22	6.82	
	7x016	25+25	6.00	
	7x017	30+30	5.00	
	7x018	35+35	4.28	
	7x026	40+40	3.75	
	7x025	45+45	3.33	
	7x033	50+50	3.00	
	7x028	110	2.72	
	7x029	220	1.36	
	7x030	240	1.25	
500 VA 140 x 60mm 4Kg Regulation 4%	8x016	25+25	10.00	**£14.38** + p&p £2.40 + VAT £2.52 TOTAL £19.30
	8x017	30+30	8.33	
	8x018	35+35	7.14	
	8x026	40+40	6.25	
	8x025	45+45	5.55	
	8x033	50+50	5.00	
	8x042	55+55	4.54	
	8x028	110	4.54	
	8x029	220	2.27	
	8x030	240	2.08	
625 VA 140 x 75mm 5Kg Regulation 4%	9x017	30+30	10.41	**£17.12** + p&p £2.55 + VAT £2.95 TOTAL £22.62
	9x018	35+35	8.92	
	9x026	40+40	7.81	
	9x025	45+45	6.94	
	9x033	50+50	6.25	
	9x042	55+55	5.68	
	9x028	110	5.68	
	9x029	220	2.84	
	9x030	240	2.60	

ALSO AVAILABLE
Sizes up to and including 5KVA are manufactured to order.

The benefits of ILP toroidal transformers
ILP toroidal transformers are only half the weight and height of their laminated equivalents, and are available with 110V, 220V or 240V primaries coded as follows.

IMPORTANT Regulation — All voltages quoted are FULL LOAD. Please add regulation figure to secondary voltage to obtain off load voltage.

For 110V primary insert "0" in place of "X" in type number
For 220V primary (Europe) insert "1" in place of "X" in type number
For 240V primary (UK) insert "2" in place of "X" in type number
Also available at Electrovalue, Maplin.

NEW PRODUCTS

HYBRID REGULATOR MODULES

The HR314 and HR614 regulated power supplies provide a constant 13.8 volt d.c. output at up to 3 Amp or 6 Amp respectively. The modules are encapsulated to an integral heatsink and are fully short circuit protected making them suitable for home or bench running of CB, car stereos or any 12 volt d.c. equipment required for many hobby or professional applications.

HR314 £10.23 inc. VAT
HR614 £18.51 inc. VAT

TECHNICAL SPECIFICATIONS

MODULE	HR314	HR614
Output Voltage	+13.8v ±5%	+13.8v ±5%
Output Current	Up to 3A	Up to 6A
Current limit (nominal)	3.5A approx	7A approx
Maximum Input Voltage	+30v	+30v
Minimum Input Voltage	+16v	+16v
Maximum Input Voltage for nominal output current	+20v	+20v
Maximum output current at 30v input	1.8A approx	3.5A approx
Output ripple (100Hz) See Note 1	<10mV rms	<10mV rms
Size in mm.	76 x 68 x 40 high	120 x 78 x 40 high

POWER SUPPLY UNITS: comprising toroidal transformer plus 90 x 50 x 55 mm high printed circuit board containing smoothing and rectification

PSU31X Suitable for running one HR314 at full rated current. £13.17 inc. VAT
PSU56X Suitable for running one HR614 at full rated current. £19.13 inc. VAT

For 110v operation insert 0 in place of X – brown primary leads.
220v (Europe) operation insert 1 in place of X – pink primary leads.
240v (UK) operation insert 2 in place of X – orange primary leads.

For mail order please make your crossed cheques or postal orders payable to ILP Electronics Ltd. Barclaycard/Access welcome. Trade orders standard terms.

Post to ILP Electronics Ltd. Graham Bell House, Roper Close Canterbury CT2 7EP Kent England
Telephone (0227) 54778. Telex 965780

ILP ELECTRONICS LTD.

WW – 019 FOR FURTHER DETAILS

www.americanradiohistory.com

OPUS AUTUMN OFFERS

JVC 14" COLOUR MONITOR OFFER

This month's offer is another winner - a consignment of 14" R.G.B. colour monitors manufactured by J.V.C. - at prices never seen before in the U.K.
Suitable for use with BBC Micro.

Lynx, Oric, Apple II, Apple III and IBM etc.
It's safe to put a cheque in the post today. Because if you find someone who's cheaper, we'll refund the difference.

RGB MEDIUM RES £199

Resolution, 370×235. Pixels.
Display, 80 characters × 25 lines. Slot Pitch 63mm.
Input Video - RGB Analogue with TTL input.
STNC - Separate SYNC on RGB. Features, On/Off switch with pilot light. Brightness control.
Power 220/240V 50/60HZ.

RGB HIGH RES £299

Resolution, 580×235. Pixels.
Display, 80 characters × 25 lines. Sloth Pitch 41mm.
Input, Video - RGB Analogue with TTL input.
SYNC - Separate SYNC on RGB.
Features, On/Off switch with pilot light.
Brightness control. Power, 220/240V 50/60HZ.

* Fast ex-stock delivery.
* 1 year warranty.
* Quantity and Educational discounts available.

DISC DRIVE DISCOUNTS

* Japanese manufacture.
* Slimline * Low Power Consumption.
* Ideal for use with BBC, Dragon, etc.

Canon MDD 6106 S/S 40 Track
100K S.D. 200K D.D. **£129.95**
National Panasonic D/S 40 Track
200K S.D. 400L D.D. **£159.95**
Cases and Leads as for TEAC.

TEAC DISC DRIVES

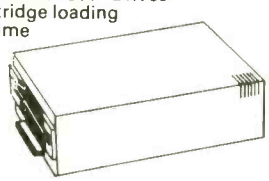
* Latest technology
* ½ height * Fast access time.
* Direct drive mechanism.
* Hardware 40/80 switchable.

TEAC 55A - S/S 40 Track
100K S.D. 200K D.D. **£139.95**
TEAC 55F - D/S 80 Track
400K S.D. 800K D.D. **£229**
Case to hold 1 drive **£9.95**
Dual case with PSU **£39.95**
P. Lead **£5** Ribbon Lead **£12**
Dual Ribbon Lead **£15**

NEW OPUS 3" MICRODRIVE LOOK

The first nationally available dual sided 3" Drive offering 500K. Capacity.

* 200K. Formatted S.D.
* 400K. Formatted D.D.
* Japanese Manufacture
* Fully compatible with 5¼" Drives
* One touch cartridge loading
* 3 ms. Access time
* Direct Drive



Single Drive * 200K/400K. Only **£199**
Dual Drive * 400K/800K. Only **£399**

FREE on first 100 orders received

We will supply case and leads free of charge.

VIEW DATA TERMINALS PRESTEL

Built-in modern Slimline design

ONLY £199
LIMITED QUANTITY
Green characters/black background 24 lines × 40 characters

12" GREEN SCREEN MONITOR

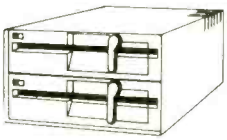
One year warranty 22 MHZ
Ex-stock delivery. Limited quantity
Phono Connector. Only **£69.95**
Lead to connect to BBC **£3.95**

CASED DRIVES

Complete with all Leads and ready to run - Case has PSU.

* Dual 200K. Drive **£319.95**
* Dual 400K. Drive **£349.95**
* Dual 800K. Drive as illustrated.

40/80 Switchable.



800K
£499.95

ACORN D.F.S. NOW IN STOCK

SEE US AT: PCW Show – Stand 284
BBC Nottingham – Stand 23

MEDIA

Disc Cartridges 1 off **£4.95**
Pack of 5 **£22.50**

SEE US AT THE PCW SHOW –
BARBICAN/STAND
and
BBC MICRO USER SHOW
NOTTINGHAM
* STAND

NASHUA FLOPPY DISCS

Minis		8" Discs	
S/S S/D	£16.95 for 10	S/S S/D	£17.95 for 10
S/S D/D	£19.95 for 10	S/S D/D	£23.95 for 10
D/S D/D	£22.95 for 10	D/S D/D	£24.95 for 10
S/S 80 Track	£24.95 for 10		
D/S 80 Track	£26.95 for 10		

With full 5 year warranty. All mini discs have hub rings and a FREE plastic library case.

To Order: Add carriage at the following rates: Discs 85p. Others goods £7. Add V.A.T at 15% to total and send your order to:

Opening Hours Mon.-Fri. 9-6
Sat. 9.30-1.30

OPUS SUPPLIES

158 Camberwell Road, London SE5 0EE
Tel: 01-701 8668 (3 lines)
01-703 6155/6/7

Government and Educational orders welcome

WW – 038 FOR FURTHER DETAILS

www.americanradiohistory.com

Wireless world
FOR EVERYTHING IN ELECTRONICS

Editor:
PHILIP DARRINGTON
01-661 3128

Deputy Editor:
GEOFFREY SHORTER, B.Sc.
01-661 8639

Technical Editor:
MARTIN ECCLES
01-661 8638

Projects Editor:
RICHARD LAMBLEY
01-661 3039

News Editor:
DAVID SCOBIE
01-661 8632

Drawing Office Manager:
ROGER GOODMAN
01-661 8690

Technical Illustrator:
BETTY PALMER

Advertisement Manager:
BOB NIBBS, A.C.I.I.
01-661 3130

BARBARA MILLER
01-661 8640

Northern Sales:
HARRY AIKEN
061-872 8861

Midland Sales:
BASIL McGOWAN
021-356 4838

Classified Manager:
BRIAN DURRANT
01-661 3106

IAN FAUX
01-661 3033

Production:
BRIAN BANNISTER
(Make-up and copy)
01-661 8648

Publishing Director
DAVID MONTGOMERY
01-661 3241

The persuaders

In the long term, it will probably be of benefit to the population as a whole to be aware of and familiar with 'new technology'. In a matter of a few years, people will, perhaps, come to accept the use of computers, interactive services, automatic manufacture and all the other aspects of life in the 'eighties. Maybe it will make for a happier life, given that jobs can be found or that the use of enforced leisure can be made productive. But whether a post-Orwell society is to be acceptable or not, it is disturbing to hear that the Government is to spend many thousands of pounds on persuading us that technology is good for us. And it is even more worrying that the money is to go towards the support of university research into the best ways of convincing the population that next year is only coincidentally 1984 –" . . . to secure greater acceptance of new technologies by developing their positive aspects and minimizing their negative aspects . . ." in the words of a DTI report.

Their new role of advisors on the techniques of public relations may possibly cause some of the researchers furiously to think. While it is generally conceded that the practical application of research is nowadays a praiseworthy object – in additon, of course, to pure research in the accumulation of knowledge with no immediate application – it is a legitimate view that scientists ought to be concerned rather more with defining the truth than with assisting the Government to manipulate it.

The acceptance or otherwise of technology by the public is a matter for the public itself to decide. Teach them the benefits, by all means, but do not try to conceal – "minimize" – the drawbacks. A home computer may well fill the leisure time of a lathe operator with transports of delight, gaining a whole-hearted convert to the concept of information technology. But when he discovers that just such a computer is going to operate his lathe and make him an ex lathe operator, he will not find it easy to listen to anyone wanting to minimize the negative aspect of his experience. He might even express the opinon that someone could, perhaps, have mentioned the possibility of redundancy to him before the event, instead of accentuating the positive and eliminating the negative.

What these social science researchers are being asked to do is suspect and should be examined very carefully before research contracts for the Government are taken on. The very most a scientist should do in these circumstances is tc investigate the possible consequences of a comprehensive embrace of technology in all human activities and to lay the options before the public. Once the facts and all the prognoses are present, we need no accentuation or minimization of the truth to help us decide what kind of society we wish to live in. To suggest otherwise is to credit politicians with the possession of greater wisdom than 60 million of the rest of us – a proposition which some may be disposed to question.

www.americanradiohistory.com

COMMUNICATIONS

Pure and applied

Recently the Royal Society organized a valuable one-day colloquium on research that brought together some 70 engineers, scientists and academics whose work contributes to either the commissions of the International Union of Radio Science (URSI) or the more down-to-earth study groups of the International Radio Consultative Committee (CCIR). This could be the forerunner of annual meetings to bring these pure and applied groups into closer touch with each other's work and objectives.

Whether such laudable aims will ever be met fully remains to be seen. The meeting made evident how wide a gap currently exists between research scientists and those concerned with the practical operation of systems for telecommunications, maritime and aeronautical radio, military systems and broadcasting. Neither side seems happy with the way the spectrum is parcelled out and the pecking order of research projects.

It is also clear that the impact of digital techniques is tending to distort the pattern of university and industrial training. Several speakers spoke of a growing shortage of radio-frequency and radio-propagation specialists, resulting from students and teachers preferring the mathematical certainties of digital electronics to the more vague, but often more challenging, analogue systems. Then again, r.f. propagation studies and research projects tend to involve time-scales appreciably more than three years and cannot be easily fitted into university courses.

The academics are also frustrated because the decisions of CCIR, spectrum regulation, etc. are seldom determined by the solutions of pure science, even when available, but more often by political and commercial considerations on the principle of 'the least objectionable to the greatest number'. Several speakers referred to the great gulf that exists between radio physics and practical applications. The academics stressed the difficulty of providing input to CCIR and other international groups. Those who cannot afford to attend the long CCIR meetings find their thoughts are overshadowed by "strong characters with their own pet ideas." Input from non-attenders is often wasted.

Using millimetres

Several of the speakers at the Royal Society meeting concentrated on the renewed interest in utilizing frequencies between 30 and 300 GHz, though paying tribute to the early pioneers such as Bose in India who carried out some surprisingly sophisticated work in the era of spark transmission. There was also renewed interest during the period 1947 to 1978 for the proposed telecommunications trunk waveguide system, involving frequencies between 30 and 110 GHz, finally abandoned in 1978 in favour of optical fibres.

Free propagation is much affected by the absorption bands though, perhaps surprisingly, communications interest is often concentrated on the frequencies with especially high absorption. Such frequencies are ideal for short-range covert communications links that effectively are immune to detection, interception or jamming.

In a review of British and European firms working on millimetric components and systems, Patrick Sargeaunt (Marconi Research Centre) mentioned EMI at Wells, GEC Hurst Laboratories at Wembley, Philips at Redhill, Plessey at Caswell, EEV (magnetrons), etc. Systems work includes 25 GHz satellite systems (GEC-Stanmore), 35 and 95 GHz radar (EMI, Decca, Marconi, British Aerospace), 30 GHz British Telecom links, 40 GHz AEG-Telefunken railway communications, 30-900 GHz modelling techniques (EMI-Wells), 300-500 GHz receivers (ESA) and measurement techniques up to 1THz at NPL.

Aerial puzzles

Almost every m.f. broadcasting station uses some variation of the vertical monopole aerial, with either a single omnidirectional element or a directional phased-array, based on the classic work of Dr George Brown and his RCA colleagues in the 1930s. For h.f./v.h.f. communications, the quarter-wave element is often raised and the ground system of up to about 120 buried earth radials replaced by a few elevated and insulated radials.

One would have imagined that by now both theory and practice of such aerial systems would have been fully and unambiguously developed. Yet recently a surprising number of controversies have arisen.

For example, Archibald Doty, together with two other retired engineers in the USA, has shown the advantages of the once-popular "counterpoise" or elevated ground-screen, noting that the currents flowing in buried radials are not, as conventionally postulated, uniform but depend upon ground conductivity in the immediate vicinity of the individual wires. Les Moxon has similarly shown the value of counterpoise systems and has also drawn attention to the common misconception that the input impedance of a groundplane antenna with horizontal radials is 36 ohms, the same as for grounded monopoles with an extensive earth system; he notes that Brown's original papers showed clearly that the correct figure was nearer 18 ohms, though this was subsequently overlooked in many later standard text books.

In *IEEE Trans. on Broadcasting* (Vol. BC-29, No 1, March, 1983) Wright, Klock and Jubera show that the feed impedances of practical m.f. broadcast monopoles often vary greatly from the theoretical value. They have been able to prove that much of this variation is due to the effect of guy wires, previously not taken into consideration in calculating the impedance.

Helically-wound loops

For many years there have been determined efforts to improve the radiation efficiency of miniature h.f. transmitting aerial elements. Loading coils, top-hat capacitances, folded elements, ferrite-loaded elements, single-turn and multi-turn small loops, the normal-mode helix: all these and other techniques have been used with some degree of success, but all imposing compromises.

In theory any element, no matter how small in terms of wavelength, can radiate all the power fed to it; in practice severe difficulties are experienced in feeding energy into a short element without losing most of the energy in the coupling networks, incurring significant power losses due to the very low radiation resistance relative to ohmic losses, and the narrow bandwidth of high-Q elements.

Alec Clelland, DJOFL/G3UUQ, has drawn my attention to a recently published European Patent Application (EP 0 043 591 A1) by James F. Corum of West Virginia. This covers a large family of aerials based on the reduction in size of a full-wave loop element by winding it helically in the form of a torus. The conductor is configured to establish a closed standing wave path to inhibit the velocity of propagation and support a standing electromagnetic wave. The inventor claims that although such elements can have a much smaller physical size than existing aerials they possess greater radiation resistance and hence greater efficiency than conventional loop aerials of similar size, and can radiate controllable mixtures of vertically, horizontally and elliptically polarized waves. He describes practical examples of such aerials for use from l.f. to v.h.f., using circular and square loops for broadcast, communications, amateur radio and c.b. frequencies. Bandwidth, however, would appear to remain restricted.

Hazards

The American Center for Disease Control, Atlanta, has recently warned that many r.f. dummy loads manufactured as recently as the late 1970s used cooling oil containing polychlorinated biphenyls (PCBs), a man-made chemical that has been linked with liver cancer. Even fumes from a hot-running load are stated to be dangerous in poorly ventilated situations.

www.americanradiohistory.com

COMMENTARY

PCBs were used in the UK for about 40 years until 1977 in oil-cooled transformers, high-voltage and fluorescent-lamp capacitors, dummy loads, etc.

A legal battle in New Jersey is centred on the question of possible health hazards from hand-held transceivers. General Electric (US) is being sued by the father of a 14-year-old boy, who alleges negligence in not providing the warning recommended by the US federal government in 1973. If the claim succeeds, American amateurs fear the case could be used as a basis for local authority legislation that might severely restrict the use of hand-held amateur radio. It is generally believed that hand-portables with an output of less than about 5 watts can be used without risk, even with short normal-mode helix aerials not far from the eyes.

Aerial tower restrictions in Burbank, Illinois are being legally contested by radio amateurs on the grounds that they represent a violation of constitutional rights of free speech and civil rights.

Here and there

An American study by International Research Development foresees the development of combined power and fibre optics cables which would carry into homes not only tv programmes and all interactive telecommunications but also electric power. The power cable would provide the necessary supportive package for the fragile glass fibres.

An investigation by NHK of Japan into the feasibility of introducing s.s.b. into h.f. broadcasting suggests that in a transitional period the carrier could be reduced by 6dB to permit continued use of envelope detection. Later 12dB suppression would be used with synchronous detection. Tests over various paths have underlined the advantages of s.s.b. including lower susceptibility to selective fading distortion. Carrier suppression of more than 12dB, however, would lead to degradation of quality due to the difficulty of achieving proper carrier extraction for synchronous demodulation.

Recently I reported the use by 50 American stations of the Harris linear a.m.-stereo system: by early summer the number had risen to 67, but the more interesting development is that this includes 10 m.f. stations in Australia and New Zealand, and also Radio Mundo Brazil.

RCA chairman, Thornton F. Bradshaw, has established a $100,000 grant for the electrical engineering department of Purdue University in memory of television pioneer Dr Vladimir Zworykin who died last year at the age of 92. Zworykin received more than 120 U.S. patents ranging from television to medical electronics.

AMATEUR RADIO

Return to Post Office

On the day following the publication of the Merriman Report, the Department of Trade and Industry announced the transfer, from September 19, of amateur radio licensing to the Post Office from the Radio Regulatory Division, now part of DoTI. This is expected to lead quickly to computerization of the records and to reduce the time in dealing with applications to a maximum of ten days at peak times and five days normally. Applications will be processed by post when sent to: Radio Amateur Licensing Unit, Chetwynd House, Chesterfield, Derbyshire S49 1PF (telephone Chesterfield (0246) 207555) who will also issue the application forms. Amateur radio was administered by the Post Office for many years until the setting up of the short-lived Ministry of Posts and Telecommunications.

While most amateurs, particularly those who have recently passed their RAE, will welcome the promised speed up in licensing process, there is some fear that this change is a further step towards making amateur radio 'up-market c.b.' as a form of revenue-collecting, leisure-time hobby rather than at least to some degree a self-training and experimental service of technical investigations in support of radio science and technology. The vast increase in licences over the past decade to 48,000 reflects the introduction of the Class B v.h.f.-only licence and the multi-choice form of RAE, combined with the complete absence in the UK of any form of incentive licensing.

With the majority of its licensed members now holding the Class B licence, RSGB policy appears to be changing. The 1983 president Don Baptiste, CBE, is on record as stating "the Class B permit is in no way to be regarded as inferior to the Class A version but simply reflects an interest in v.h.f./u.h.f. technique rather than in h.f.-bands communications". The Society claims there is "little or no demand" for a novice licence intended to encourage training in Morse. A number of Class B members are lobbying for the society to support code-free licences for h.f. operation.

85% of "optimum"

In the August "Letters to the Editor", Paul Thompson suggested that I was mistaken in believing that the Woodpecker roughly follows the m.u.f., and thought it more likely that the troublesome over-the-horizon radar follows the "optimum traffic frequency" (f.o.t.). While I am not privy to the Russian procedures, I believe this suggestion arises from a common misconception of the definition of f.o.t. Far from being a true "optimum frequency" it is a purely notional frequency, usually taken as 85 per cent of the m.u.f., in order that h.f. communications links are not disrupted by the considerable daily and hourly variations and errors in the predicted values of the m.u.f. A frequency-agile system such as the Woodpecker, that disregards IFRB frequency assignments and Radio Regulations, would clearly be made more effective by keeping as near to the m.u.f. as possible. It is indeed a typical piece of misplaced engineering jargon that defines f.o.t. as the *optimum* frequency!

There is, however, an important exception to the idea that one should always use the highest possible frequency for a specified path. This is for around-the-world "long-path" transmissions where using the daylight m.u.f. may result in much less favourable propagation than using a "darkness" or grey-line chordal-hop path at much lower frequencies. A good example is to be found in using 10 or 14MHz bands to contact Australia in the European mornings even when the daylight m.u.f. may well be above 21MHz.

In brief

Headquarters station of the RSGB at Potters Bar, normally GB3RS, is additionally using the call GB3WCY (World Communication Year) on Friday afternoons until the end of 1983, mostly on the 7MHz band . . . American amateurs are no longer legally required to keep a detailed station log, one result of F.C.C. "deregulations" . . . Ray Cracknell, Z22JV, beacon operator and transequatorial propagation pioneer, whose efforts to renew his British amateur licence were noted in the July issue is, after all, being granted his old G2AHU licence without having to take the RAE and Morse test . . . The next Radio Amateurs Examinations will be on December 5, 1983; March 19 and May 14, 1984 . . . RAE courses and/or Morse classes are starting this September in a number of further education centres, etc. RAE classes at Basildon, Birmingham, Colwyn Bay, Crawley, Derby, Dudley, Durham, Heckmondwyke, London (Acton and Brixton), Manchester, Melton Mowbray, Newcastle-upon-Tyne, Newquay, Nottingham, Orpington, Morley, Portsmouth, St Austell, Stamford, Turnford, Walsall, Wakefield and Witney; Morse classes at Bromsgrove, Cheshunt, Grantham, Heckmondwyke, London (Acton, Beckenham) and Manchester . . . The Midlands VHF Convention will be held at the British Telecom Training School, Stone, Staffs on Saturday, October 15 . . .

PAT HAWKER, G3VA

www.americanradiohistory.com

Strain-gauge weighing scale

A range of 0.1g to 1kg, with a high degree of linearity and low drift, is obtained from a novel, simply made load cell and an improved d.c. amplifier. The instrument will also measure temperature, using a thermocouple.

by John L. Linsley Hood

The old familiar swinging arm balance has now almost entirely disappeared from our shops and laboratories, to be replaced by electronic weigh scales with fixed-position pans and digital displays, a change which will be regretted by very few of those who have to use them in the course of their work. Such a scale is a very convenient thing to have around the house – though at the moment, rather expensive.

Since one of my hobby interests is photographic chemistry, in which the weighing out of chemicals for various processing solutions is a frequent activity, my thoughts have turned from time to time towards the construction of such an instrument. In the consideration of this, my view has been coloured by the relatively limited facilities and skills which are at my disposal in the mechanical field, and the solution which I have adopted has therefore tended to favour electronic rather than mechanical complexity. Manufacturers would choose a different compromise – but then they are not contemplating a one-off exercise.

The basic elements of an electronic balance, to give it its more usual name, are a load cell, some form of electronic amplifier having zero and gain adjustment facilities, and a digital display system. Since digital display elements are now readily available commercially, at a sensible price, this part of the task presents no problem. The load cell is a different matter, alas, and my own searches through manufacturers lists did not disclose any suitable cell at less than several hundred pounds in cost, which would defeat the purpose in mind.

The methods available for determining the weight of a body placed on a weighing pan fall into three broad categories; a simple strain gauge load cell; a pan suspended on a spring mount with a linear displacement transducer attached to the suspension so that the displacement under load produces a suitable signal output; and a force balance of some kind, such as an electrically energised solenoid in which a magnetic plunger is held against the applied load by electromagnetic force, its position being held substantially constant by some closed-loop servo-system based on a position sensing element, which increases the current through the solenoid, as the load increases, to maintain the status quo.

Other systems have been employed for this purpose, such as those based on a resonant element whose period of artificially sustained low-level oscillation changes as the mass on the weighing pan is altered, but the three listed above represent the main stream of electrical weighing systems.

Of the methods listed, undoubtedly the spring system with a displacement transducer would have the greatest ability to withstand overloads and misuse, but of the non-contacting displacement transducers, the linear differential transformer is the most suitable, and this is an element which would be difficult to construct for oneself while preserving adequate linearity. The idea of using a differential grating, with a photocell, and simply counting the alternating cycles of light and dark was a beguiling one, but the finest grating easily available (old Dufaycolor reseau) offered only 40 l/mm, and if a range of 10,000:1 or even 1000:1 was sought, the displacement would need to be substantial, with consequent problems of linearity.

Similarity, with a desired maximum load of 1kg, a suitable solenoid for a force balance would need to be a massive one. I therefore returned to the consideration of possible strain-gauge systems which might possibly meet the basic specification of a measuring system which would operate over the range 0-1kg, with a possible resolution of 0.1g. To avoid the need for any sophisticated engineering in the suspension system, it was desired that there should be no moving or pivoted elements, and that the total suspension should be of the taut wire form.

These considerations led to the evolution of the structure shown in Fig. 1. In this a pair of fixed members A-A served as anchor points for resistance wire elements MM, NN, SS, TT, connected to the central movable bushes B and C urged outwards to tauten the wire elements by the tensioning screw Z. Under a

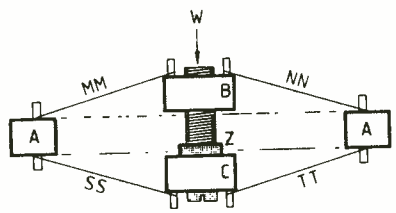


Fig. 1. Wire load-cell principle. Anchor ring A is fixed, B and C move and vary tension on wires.

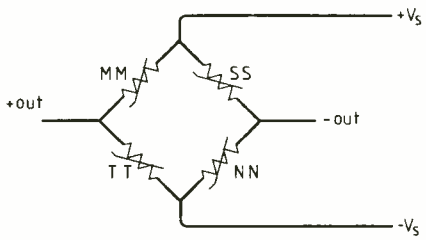


Fig. 2. Connexion of wire elements to form Wheatstone bridge.

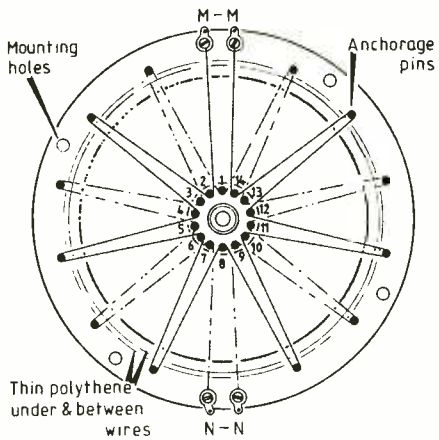


Fig. 3. One side of load cell. Where wires MM and NN cross, plastic film used for insulation.

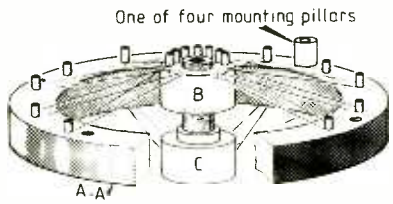


Fig. 4. Completed cell.

www.americanradiohistory.com

downward load W, the elements MM and NN become less taut, and the elements SS and TT become tighter. If then, the four elements are connected in the Wheatstone bridge form shown in Fig. 2, there is a resultant electrical unbalance, and a measurable output voltage if a load is applied to B-C.

In a practical form, the member A-A is an annular ring and B and C are smaller discs mounted in the centre of this, as shown in the plan view of Fig. 3. In the prototype, the strain gauge element was made from a 4×4in square of ⅜in 'Perspex' sheet, from which the outer ring, 4in o.d., and 3in i.d., and the two inner bushes each ¾in o.d. were cut. A series of 14 1.3mm holes was then drilled, uniformly around the periphery of the inner bushes, and a corresponding series of 12 similar holes, plus two pairs of tapped holes to hold solder tags, was then made in the outer ring, so that the whole could be strung with resistance wire, as also shown in Fig. 3. The wire starts and finishes at the solder tags and is looped around standard Vero type solder pins inserted into the holes, and anchored there by applying a hot soldering iron to the head of the pins so that they move inwards under the influence of the applied heat and pressure, and cause the softened Perspex to grip them firmly, when it cools.

The mechanical structure of this load cell is shown in Fig. 4, and the central bushes, in 'exploded view', in Fig. 5. The tensioning screw 'Z' was made from an 0BA cheese-head screw, on to the head of which a piece of ¼in brass spindle was soldered, with a screw slot on the lower end to allow it to be rotated to tension the wire elements.

After some inward debate, supported by experiments, it was decided to make the wire elements from 44s.w.g. Nichrome, obtainable (if one is patient) from the Scientific Wire Co, of London E4. Strain gauges are usually made from one of the zero temperature-coefficient Cu-Ni alloys, such as 'Eureka' or 'Constantan.' However, Nichrome has a higher specific resistance, which is helpful, and is very much stronger, which avoids the aggravation of the wire breaking during the threading up.

A relatively crude test suggested that the breaking strain of the 44s.w.g. Nichrome is in excess of 1kg, so that if the angle of the wire elements to the horizontal is 20°, and there are 28 of these bearing the downward load, the cell should carry 28.sin 20° kg (less the pretensioning force, say 1.2kg) before rupture. Since this is some 8.3kg, it would appear that the structure would be adequately strong for its purpose. As even finer wire, such as 46s.w.g., would undoubtedly be usable, with a higher gauge output, if the awkwardness of handling such a fine wire could be tolerated. Some form of jig such as shown in Fig. 7, to hold the central bushes in position is essential during threading up, and some care must be exercised both to ensure that the loops of wire sit against the Perspex at the base of the pins, and that the threading tension is

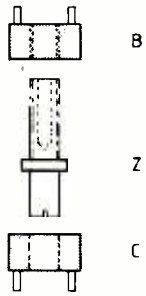


Fig. 5. Load-cell tensioning screw. centre bushes and

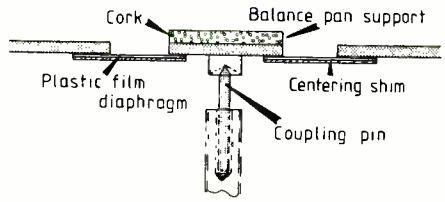


Fig. 6. Pan mounting. Coupling pin is pointed to ensure load is applied vertically when object in pan off-centre.

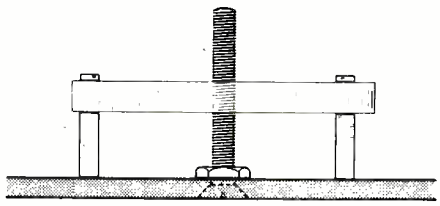


Fig. 7. Wiring jig for load cell.

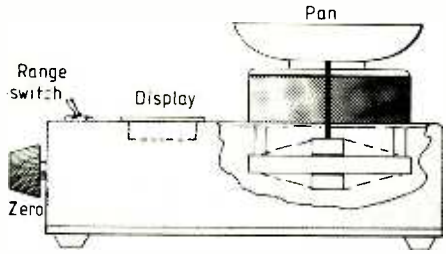


Fig. 8. Layout of instrument.

the same on both sides of the annulus. Otherwise, when the tensioning screw is tightened up, the screw will tilt over at an angle to the vertical, which will impair the performance of the bridge. It is well to be reconciled to the probability that one will have to go through this exercise several times before achieving a reasonably satisfactory result, and it is prudent to refrain from cutting off the stray ends of the wire until the result has been passed as satisfactory.

As constructed, the bridge elements each have a resistance of about 100 ohms, and with a bridge supply of approx. ±3.4 volts d.c., the d.c. output is of the order of 2mV/100g. With a display having a sensitivity of 199mV, so that 100mV would be equivalent to 100g on the 0-199g range, an amplifier gain of about 50× is required. Although something a bit better than the standard '741' is needed as the amplifier element, there are some very good i.c. op-amps available which have negligible noise or drift under these conditions. The extra complexity of an a.c. energized bridge and synchronous demodulator was not therefore thought to be worthwhile. In fact, the major source of long- and short-term drift is in the thermal sensitivity of the strain-gauge element due to the physical separation of the four component arms of the bridge. To combat the adverse effects of random movements of air within the strain gauge, two thin polythene diaphragms are placed under the position of the wires before the strain guage is threaded up, and in the final model, the whole gauge was enveloped in a single layer of cling film on top of the wire elements. This was helpful.

The choice of 46s.w.g. for the elements would increase the bridge sensitivity by some 1.76×, and would give an element resistance of about 175 ohms, which would reudce the gauge dissipation from 460mW to 240mW and help lessen thermal effects.

To lessen the extent of the sensitivity of the strain gauge to lateral components of the downward force, due to unsymmetrical loading of the pan, the top of the gauge is coupled to the pan support by a steel pin, sharpened to a point at both ends, held between a conical hole in the centre of the top plate and the bottom of the hole drilled in the tensioning screw, as shown in Fig. 6. The top plate itself is then held against lateral movement by a 'spider' made from three webs cut from 0.002in brass shim, anchored at the edge of the plate in which a suitable aperture has been cut to allow the upper scale plate to be accessible.

In my own instrument, the circular strain gauge, the electronics, power supply and display unit were mounted in a 8.5×5.5×2in diecast box, with the top balance plate and coupling linkage housed on top of it, as shown in Fig. 8. Although I feel that the choice of the positions within the box in which the separate components are to be mounted can well be left to the judgment of the constructor, the layout which I adopted was to have the display element mounted at the front of the upper face, with the main zero-adjust knob below this. The other controls were grouped on the right-hand side of the box, for the convenience of a right-handed user, and some space was left at the rear for a small, internally screened, compartment to house the power supply transformer, rectifiers and reservoir capacitors. This then left an unoccupied left-hand wall on which the small electronic amplifier panel, assembled, on a piece of 0.1in perforated 'Vero' strip. board, could be mounted on short, threaded stand-off pillars.

The unit was then finished, mechanically, by four stick-on rubber feet on the detachable lid which forms the base of the lower box, and a disc of cork was then stuck on to the upper pan plate to provide a small degree of mechanical shock isolation to the strain gauge element from items dropped upon the pan.

Electronics

As mentioned above, my deliberate choice in this design was to use the simplest practicable mechanical load measuring element and to accept the extra complexity which this would impose upon the electronic circuitry used with this. Inevitably, the problems in d.c. amplification, from such low-output signal levels as those from a strain gauge bridge,

www.americanradiohistory.com

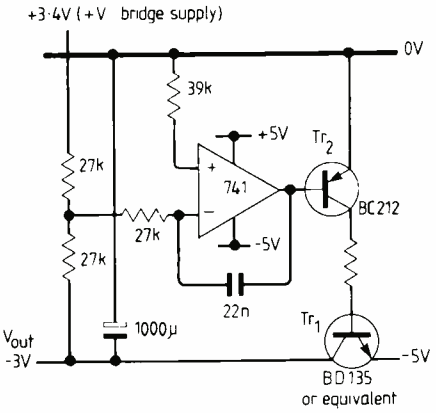


Fig. 9. Negative supply mirrors fluctuations in positive line.

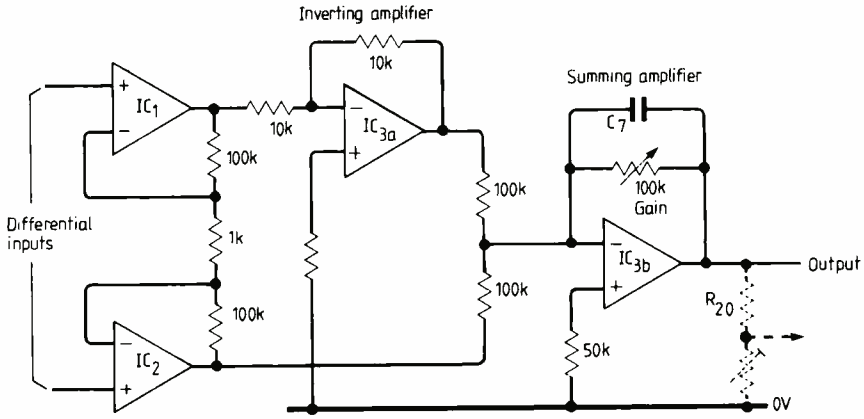


Fig. 10. Improved d.c. differential amplifier.

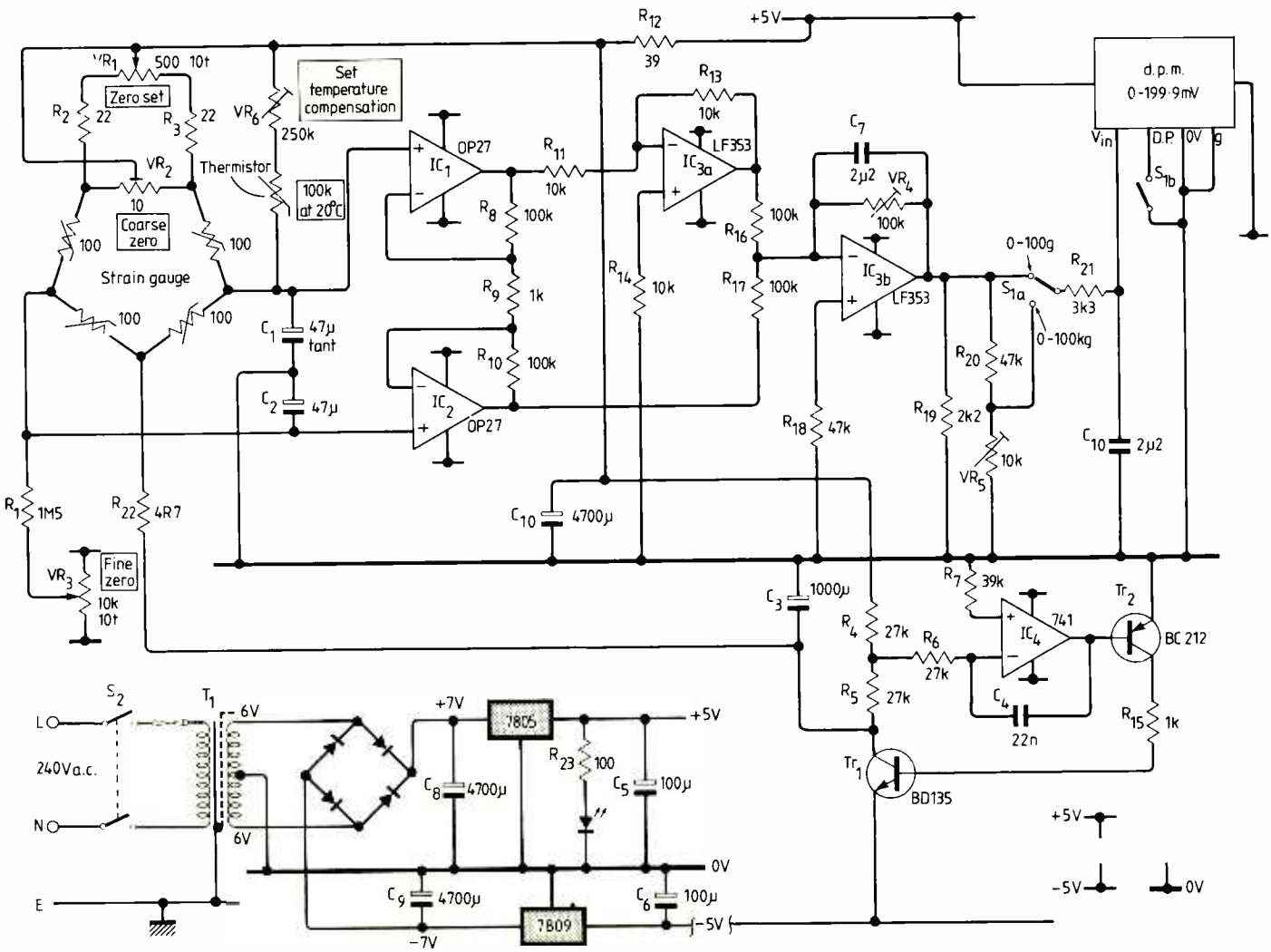
centre around the presence of zero drift. With modern i.c.s, this need not be due to inadequacies in the d.c. amplifier itself, but will arise in respect of the input signal.

The inevitable difficulty due to differential thermal effects upon the resistance wires of the load cell has already been mentioned. This can only be minimized by restricting air movement within the weigh scale housing, by using a well-sealed container box, and within the strain-gauge element by the use of thin polythene diaphragms interleaving the windings to diminish internal air cooling effects. Fortunately, in my experience using the prototype, this only affects the long-term zero setting, which is adequately stable during any one weighing for the beginning and end zero readings to be the same within the ±0.1g basic uncertainty of the reading.

However, there is a more insidious difficulty, due to random excursions of the voltage of the + and −5V supply lines. With a 2mV/100g bridge sensitivity, the required 0.1g zero stability represents 2μV. Using the standard ±5V i.c. regulators as the basic bridge supply brought home to me that random fluctuations of a few mV in their output potential, could represent common-mode voltage swings of a few mV at the output terminals of the bridge. To achieve the required input voltage stability of better than 2μV demanded a common-mode rejection capability from the d.c. amplifier of some 70-80dB. This was much greater than attainable from a low-drift op-amp used in the conventional differential amplifier mode. The first improvement in the performance of the system was therefore made by the use of a separate d.c. supply system for the negative line, shown in Fig. 9, in which the operation of the circuit is such that a negative supply is generated which closely matches, in opposite polarity, any random excursions of the positive supply line, as seen at the strain gauge bridge pick-off point at the junction of R_{12} and C_{10}.

The second circuit improvement relates to the design of the d.c. differential amplifier itself, shown in Fig. 10. The

Fig. 11. Complete circuit diagram.



www.americanradiohistory.com

normal 'instrumentation amplifier' layout employs two i.cs (as IC_1 and IC_2) arranged to have a high gain to signals applied differentially to their inputs, but only unity gain in respect of signals applied equally to both. A third i.c. op-amp is then used as a differential amplifier to reject the residual common mode output.

Unfortunately, it is impracticable to employ negative feed-back around such an op-amp differential amplifier without making the two inputs unsymmetrical, so that there is a higher gain from the non-inverting input than from the inverting one. Conventionally, this shortcoming is remedied by inserting an attenuator network in the non-inverting input limb, but this would only work for a fixed-gain stage as the differential amplifier, and would preclude the use of this stage as an active integrator to slug the response of the circuit to unwanted l.f. noise.

In the improved arrangement shown, an additional inverting stage $IC_{3(a)}$, (½LF353) is inserted in one of the output limbs from the input differential amplifier pair, so that $IC_{3(b)}$ can be used as a summing amplifier, in which common-mode signals, now presented in opposition, will cancel at the 'virtual earth' input point, while differentual signals will be added at this point. There is then no difficulty in making the gain of $IC_{3(b)}$ adjustable to provide for a full scale calibration adjustment on the 0-100g scale, and in putting a suitable value integration capacitor (C_7) across this i.c. to give a suitably 'dead-beat' response to the weigh scale reading. (This is advantageous when weighing up chemicals by pouring them into the pan, since they are likely to be lumpy, which would give an apparently jerky character to the meter reading.)

The 0-100g and 0-1kg scales are switched by an output attenuator on the output of $IC_{3(b)}$, rather than by switching VR_4, to avoid shifts in the d.c. zero from one range to the other. If suitable facilities are available for determining resistor values, R_{20} and VR_5 could be replaced by a fixed 1/10 resistive attenuator. With the 0-0.1999V digital panel meter unit employed, it was possible to switch the decimal point so that the 100g range read 100.0g and the 1kg range read 1000g, as the scale was switched.

A small 6VA 6-0-6V mains transformer powers the unit, feeding a pair of 5V i.c. voltage regulators to provide a stable voltage line for the i.cs and the bridge, unaffected by mains voltage fluctuations, and a l.e.d. is fed from the positive 5V line to warn that the unit is on.

Any convenient and suitable transistors can be used for Tr_1 and Tr_2, IC_1 and IC_2 should be a low-drift, low-noise i.c. type. In the prototype I have used the excellent OP-27 types, available from Precision Monolithics Inc., (Bourns in UK) because I had a pair of these to hand, though there is little doubt that other, less expensive, instrumentation type low-drift operational amplifiers, such as the LM725, would serve equally well. With these i.cs, the zero stability, with both inputs taken to 0V, is well within the 0.1mV output requirement over a period of 24hr, which vindicates the original decision to use a d.c. energized bridge, in that the residual problems due to differential thermal effects in the strain gauge would be present equally in an a.c. energized system. The d.c. systems avoids difficulties due to inadvertent signal coupling through wiring stray capacitances. The circuit of the complete weigh-scale amplifier is shown in Fig. 11.

Temperature compensation

Although the bridge system is very nearly fully symmetrical, inadvertent asymmetries in the mechanical construction, coupled with the physical changes, due to thermal effects, of the structure of the load cell, lead to a negative temperature coefficient in the prototype of some 5g/°C. A first-order compensation for these is provided by the thermistor/resistor network across the limb of the bridge feeding the non-inverting input.

Use and setting up

As indicated earlier, it is probable that one's first attempt(s) at wiring up the strain gauge element will be less good than those made when one has gained a little more familiarity with the problems involved in getting the wires to sit in the required positions, and with uniform tension when the tensioning screw is tightened. Fortunately, with a suitable jig to hold the separate parts of the strain gauge while the wire is applied, it doesn't take too long to pull it apart and try again. So, it is sensible to build the electronic amplifier and power supply unit before one makes the load cell so that this can be tested after it has been assembled.

A slightly disconcerting effect, initially, is the way in which the output signal will vary up and down, in a random manner, after the tensioning screw is adjusted, or readjusted, as the tensions in the individual wires in the strain gauge rosette accommodate to one another by slipping round the anchoring pins. The process can be speeded up a bit by gently tapping the tensioning screw, but ultimately one must just be patient and wait a few hours for the load cell to settle down again. This accommodation of the individual wires to a state of uniform tension is also responsible for the hysteresis (failure of the gauge to return to zero after a load has been applied and removed) which is an annoying feature commonly found in freshly constructed load cells. Normally this effect will progressively lessen as weights are applied and removed during the calibration process of setting VR_4 and VR_5, for appropriate f.s.d. readings.

If hysteresis persists, one must conclude, with regret, that the strain gauge cell has not been built adequately well, and have another go. In the prototype, the hysteresis is now, after some time in use, of the order of 0.2g following an applied load of 200g. I have, I think, in the course of developing the prototype, rebuilt the load cell five times, though some of these were in the pursuit of hoped-for design improvements. I still have the feeling that I could make it a bit better, to equal the performance given by one of the earlier versions, where I had got the wire tension particularly uniform.

The static tension applied to the wires by the tensioning screw should be adequate to make the gauge linear over the range of loads which it is desired to apply: further tightening is of no benefit.

In use, the zero adjust pot. VR_1 and the fine zero adjust pot. VR_3, both of which are 10-turn types, should be set to a position near to their mid point. The 10R coarse zero-adjust pot. (VR_2) should be adjusted, slowly, until the reading is somewhere within ±100gms on the 1kgm scale range. The zero set pot. VR_1, in parallel with VR_2 can then be adjusted to set the meter reading within the ±2gms range covered by the fine zero control,

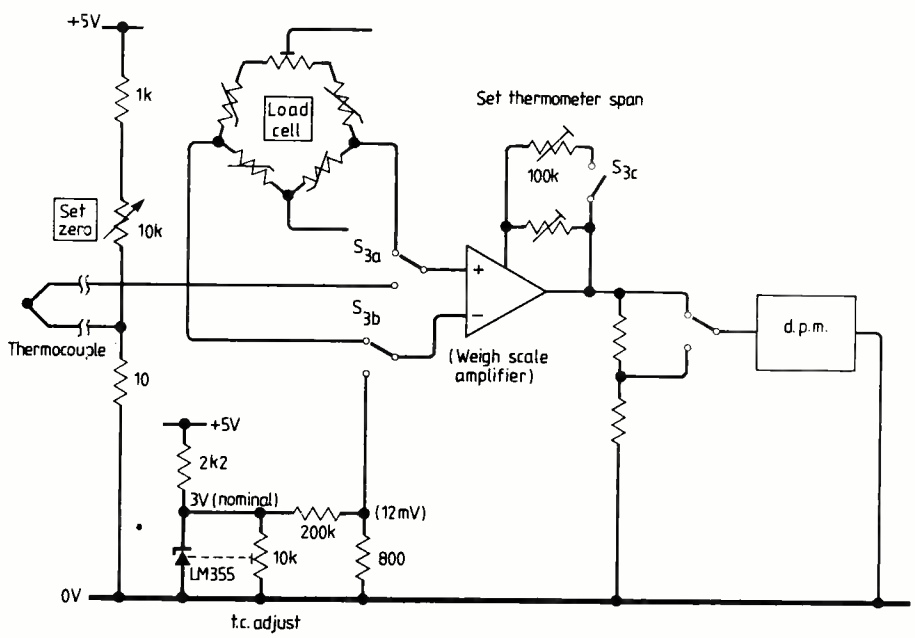


Fig. 12. Stability is such that temperature measurement can be carried out. Circuit shows offset voltage source and input switching.

www.americanradiohistory.com

which is the normal operating zero control of the instrument.

The linearity of the prototype, when checked against a set of good-quality chemical balance weights, was within 0.2% over the range 0-250gms, with the major contribution to this being the small remaining hysteresis. It is probable, therefore, that the scales could be set up adequately by pouring a measured quantity of water into a suitable vessel mounted on the weighing pan, in the absence of appropriate calibrated weights, without incurring unacceptable errors in intermediate readings.

Adjusting temperature compensation

As mentioned above, because the final strain-gauge load cell, in the prototype, was not completely symmetrical, there is a residual long-term sensitivity to changes in ambient temperature, which require the zero to be reset more often, in day to day use, than is desirable. A simple thermistor compensation circuit is therefore connected across the +3.4V supply and an input to the amplifier. (Which input is required will depend on the final strain-gauge temperature characteristics, which will depend on its construction.) The easiest way to adjust the trimmer resistor VR_6 is to put the whole instrument in a refrigerator, and then, after removal, as it warms up to room temperature, adjust VR_6 so that the scale reading drifts neither up nor down.

The total power consumption of the instrument is less than 2 watts, and there is no detectable change in the temperature of the housing, compared with the ambient, over a 12 hour period. To prevent errors due to air currents entering the instrument through the exit hole surrounding the load cell shaft, a thin polythene diaphragm is fixed under the top load plate to seal the unit. If it is desired to turn the instrument over, for access to the electronics, the lid of the upper box, carrying the load plate and its coupling pin should be removed to obviate possibly heavy loads being applied to the load cell, which might affect its calibration.

The gain and stability of the amplifier unit is sufficiently good for the instrument also to be usable, with a copper/constantan or chromel/alumel thermocouple input, (40μV/°C) as an accurate digital thermometer, provided that a suitable switching input socket is employed, and an appropriate temperature-dependent offset voltage source to act as a 'cold junction' reference is provided. A suitable circuit is shown in Fig. 12.

Wheelchair word-processor

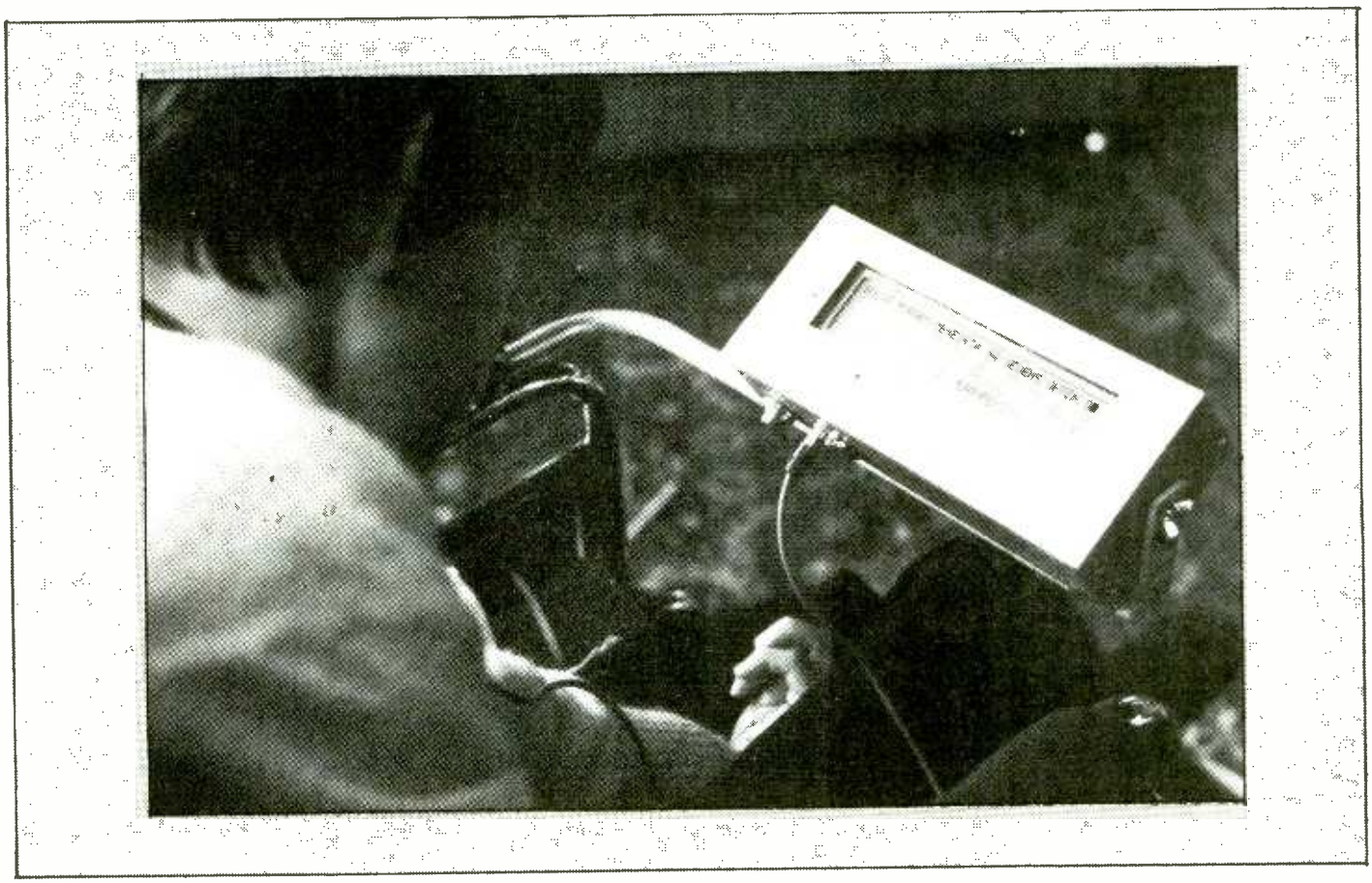
This communication aid for the disabled is not an entry for our competition, but it does show the sort of results that can be achieved by volunteers working to a restricted budget. Designed for those whose faculty of speech is impaired or perhaps lacking altogether, the Writing Box can be produced in a variety of configurations to match the needs of the individual user. The device is the work of a non-profit-making group in Belgium and cost around £300.

The liquid-crystal display shows four lines of 40 characters, while for longer texts there is memory capacity for up to 6500 characters. Writing and editing is possible using a keyboard, although users with a lesser degree of dexterity can choose from a range of unusual input devices including foot switches, eye-movement detectors, blow pipes and sound-operated switches.

The fourth line of the display can act as a menu to help in obtaining the right characters; and a subtle feature of the unit is the capability for storing and displaying messages defined by the user. For example, three switch-pushes might produce "lift me up a bit, please". In addition to this, there is a word memory holding up to 500 longer words which can be adapted to the requirements of the individual: words which would normally call for 14 or more pushes can thus be produced with four or five.

For more elderly patients there is another mode of operation, simpler to use but slower; and for children who have not yet learned to read there is even a sort of video game designed to familiarise them with the box and its method of operation.

The output of the box is available in RS232 serial code for connection to a printer. Power comes from a built-in rechargeable battery giving 11 hours of continuous operation and the unit has an energy-conserving standby mode to which it reverts when not in use.



www.americanradiohistory.com

Precision preamplifier

Many designers have not, until recently, considered op-amps a suitable choice for preamplifier designs of the very highest quality. Newer types now obtainable have changed this and Doug Self's new design exploits the 5534 op-amp

Until relatively recently, any audio preamplifier with pretensions to above-average quality had to be built from discrete transistors rather than integrated circuits. The 741 series of op-amps was out of the question for serious audio design, due to slew-rate and other problems, and the TL071/72 types, though in many ways excellent, were still significantly noisier than discrete circuitry. In an article some years ago[1] I attempted to show that it was still feasible to better the performance of such devices by using simple two or three-transistor configurations.

The appearance of the 5534 low-noise op-amp at a reasonable price, has changed this. It is now difficult or impossible to design a discrete stage that has the performance of the 5534 without quite unacceptable complexity. The major exception to this statement is the design of low-impedance low-noise stages such as electronically-balanced microphone inputs or moving-coil head amplifiers, where special devices are used at the input end.

5534 op-amps are now available from several sources, in a conventional 8-pin d.i.l. format. This version is internally compensated for gains of three or more, but requires a small external capacitor (5-15pF) for unity-gain stability. The 5532 is a very convenient package of two 5534s in one 8-pin device with internal unity-gain compensation, as there are no spare pins.

The 5534/2 is a low-distortion, low-noise device, and a typical audio stage could be expected to generate less than 0.005% t.h.d. over the range 1kHz-20kHz, leaving the residual distortion lost in the noise of all but the most expensive analysers. Noise performance obviously depends partly on external factors, such as source resistance and measurement bandwidth, but as an example consider the moving-magnet disc input stage shown in Fig. 3. When prototyped with a TL071, the noise (with a 1k resistor input load) was -69dB with reference to a 5mV r.m.s. 1kHz input. Substituting a 5534 improved this to -84dB, a clear superiority of 15dB.

Another advantage of this device to the audio designer is its ability to drive low-impedance loads (down to 500 ohms in practice) to a full voltage swing, while maintaining low distortion. This property is much appreciated by studio mixer designers, whose output amplifiers are still expected to drive largely fictitious 600 ohm loads. As a comparison, the TL071 is only good for loads down to about 2kΩ.

Architecture

As explained in a previous article[1], the most difficult compromise in preamp. design is the distribution of the required gain (usually at least 40dB) before and after the volume control. The more gain before the volume control, the lower the headroom available to handle unexpectedly large signals. The more gain after, the more the

by D. Self

noise performance deteriorates at low volume settings. Another constraint is that it is desirable to get the signal level up to about 100mV r.m.s. before reaching the volume control, as tape inputs and outputs must be placed before this. The only really practical way to get the best of both worlds is to use an active gain-control stage – an amplifier that can be smoothly varied in gain from effectively zero up to the required maximum.

If the input to the disc stage is a nominal 5mV r.m.s. (assumed to be at 1kHz throughout the avoid confusion due to RIAA equalization) from either moving-magnet cartridge or moving-coil head amp, then 26dB of gain will be needed to give the 100mV which is the minimum it is desirable to offer as a tape output. This can easily be got from a single 5534 stage, and taken together with the supply rails (±15V) this immediately fixes the disc input overload at about 320mV r.m.s. A figure such as this is quite adequate, and surpasses most commercial equipment.

One must next decide how large an output is needed at maximum volume for the 5mV nominal input. 1V r.m.s. is usually ample, but to be certain of being able to drive exotic units to their limits, 2V r.m.s. is safer. This decision is made easier because using an active gain-control frees us from the fear of having excessive gain permanently amplifying its own noise after the volume control. Raising the 100mV to this level requires the active gain stage to have another 26dB of gain available; see the block diagram in Fig. 1.

The final step in fixing the preamp. architecture is to place the tone-control in the optimum position in the chain. Like most Baxandall stages, this requires a low-impedance drive if the response curves are to be predictable, and so placing it after the active gain-control block (which has the usual very low output impedance) looks superficially attractive. However, further examination shows that (a) the active-gain stage also requires a low-impedance drive, so we are not saving a buffer stage after all, and (b) since it uses shunt feedback the tone-control stage is rather noisier than the others[2], and should therefore be placed before the gain control so that its noise can be attenuated along with the signal at normal volume settings. The tone-control is preceded by a unity-gain buffer stage with low output impedance and a very high input impedance, so that the load placed on line input devices does not vary significantly when the tape-monitor switch is operated. This brings us to the block diagram in Fig. 1. Figure 3 shows the circuit diagram of the complete preamplifier. The components

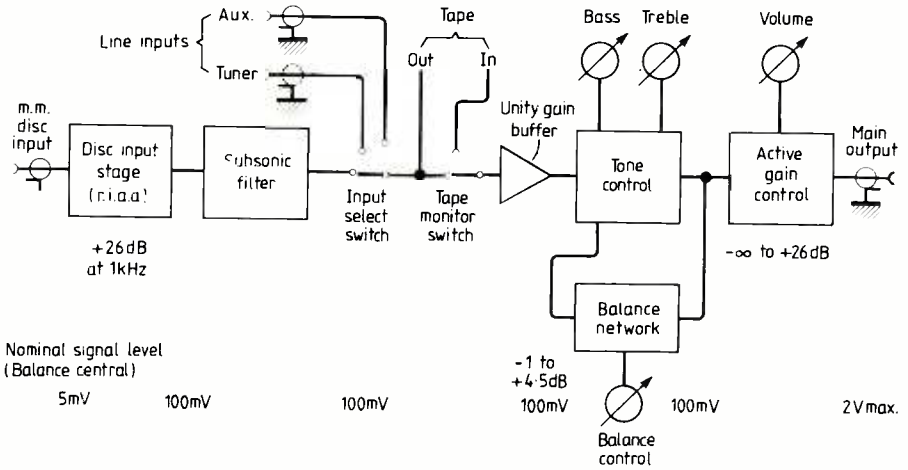


Fig. 1. Block diagram. Tone-control placed before gain-control block to reduce noise from tone-control.

www.americanradiohistory.com

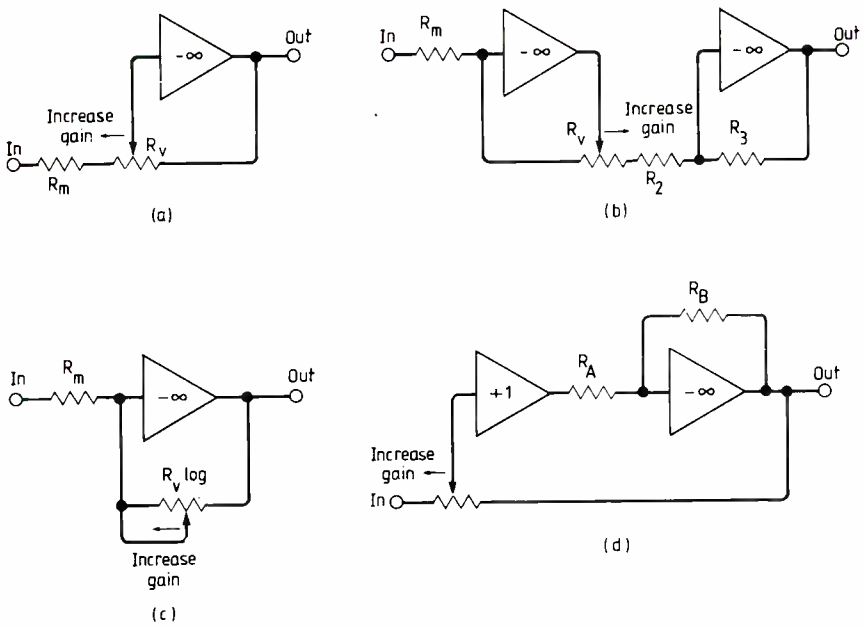
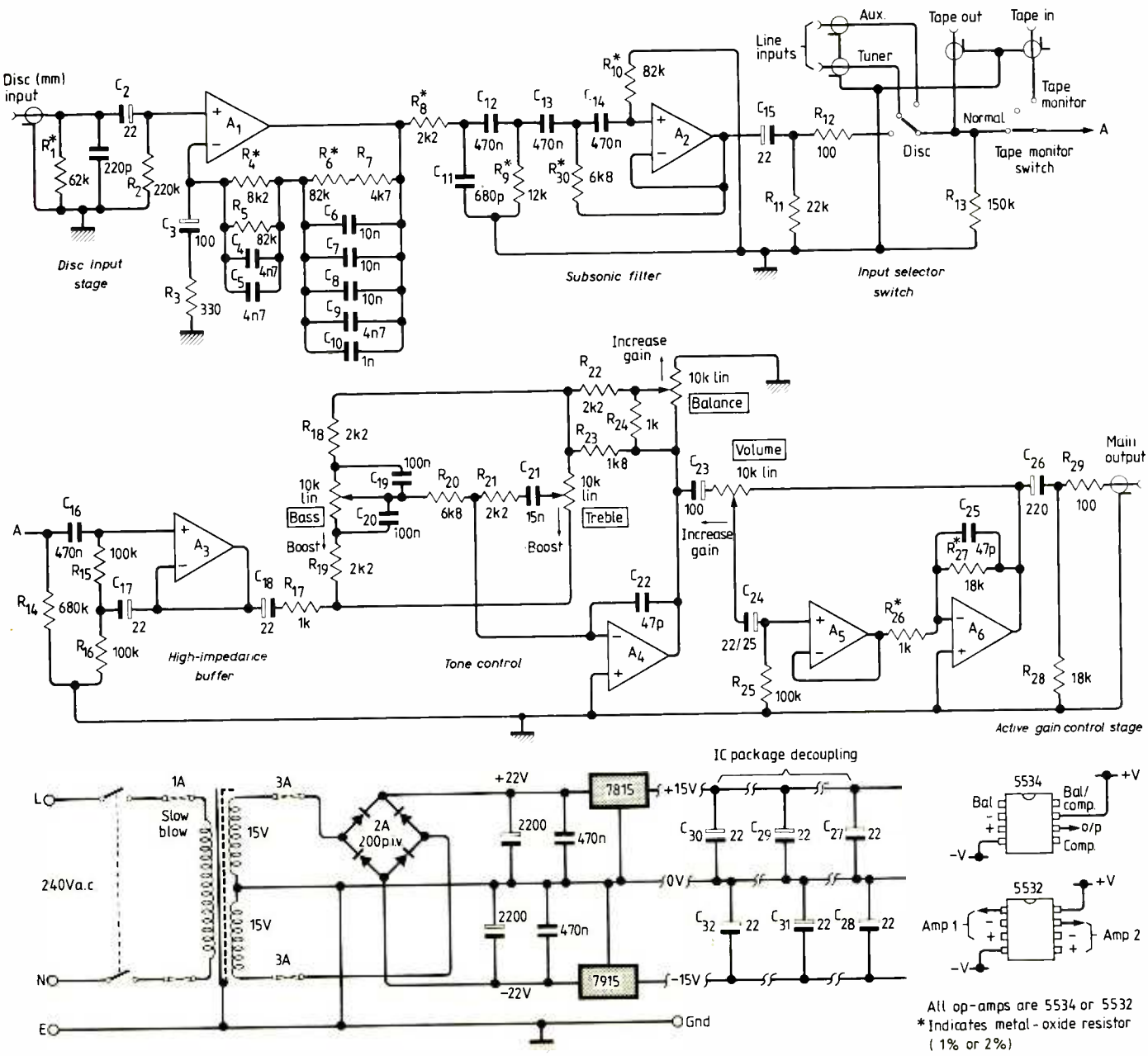


Fig. 2. Evolution of active gain-control stage. That due to Baxandall, chosen for this design, is at (d).

around A_1 and A_2 make up the moving-magnet disc stage and its associated subsonic filter. Disc preamp. stage A_1 uses a quite conventional series feedback arrangement to define the gain and provide RIAA equalisation. This provides a clear noise-performance advantage of 13dB over the shunt feedback equivalent[2], which is sometimes advocated on the rather dubious grounds of "improved transient response". The reality behind this rather woolly phrase is that the series configuration cannot give the continuously descending frequency response in the ultrasonic region that the RIAA specification seems to imply, because its minimum gain is unity. Hence sooner or later, as the frequency increases, the gain levels out at unity instead of dropping down towards zero at 6dB per octave. As described in refs. 1 and 2, when a low-gain input stage is used to obtain a high overload margin, "sooner" means within the audio band,

Fig. 3. Complete circuit diagram. Decoupling capacitors for i.cs must be close to packages.



www.americanradiohistory.com

and so an additional low-pass time-constant is required to cancel out the unwanted h.f. breakpoint; once more it is necessary to point out that if the low-pass time-constant is correctly chosen, no extra phase or amplitude errors are introduced. This function is performed in Fig. 3 by R_8 and C_{11}, which also filter out unwanted ultrasonic rubbish from the cartridge.

It was intended from the outset to make the RIAA network as accurate as possible, but since the measuring system used (Sound Technology 170 A) has a nominal accuracy of 0.1dB, 0.2dB is probably the best that could be hoped for. Designing RIAA networks to this order of accuracy is not a trivial task with this configuration, due to interaction between the time-constants, and attempting it empirically proved most unrewarding. However, Lipshitz, in an exhaustive analysis of the problem, using heroic algebra in quantities not often seen, gives exact but complicated design equations[4]. These should not be confused with the rule-of-thumb time-constants often quoted. The Lipshitz equations were manipulated on an Acorn Atom microcomputer until the desired values emerged. These proved on measurement to be within the 0.2dB criterion, with such errors as existed being ascribable to component tolerances.

Design aims were that the gain at 1kHz should be 26dB, and that the value of R_3 should be as small as feasible to minimize its noise contribution. These two factors mean that the RIAA network has a lower impedance than usual, and here the load-driving ability of the 5534 is helpful in allowing a full output voltage swing, and hence a good overload margin.

There is a good reason why the RIAA capacitors are made up of several in parallel, when it appears that two larger ones would allow a close approach to the correct value. It is pointless to design an accurate RIAA network if the close-tolerance capacitors cannot be easily obtained, and in general they cannot. The exception to this is the well-known Suflex range, usually sold at 2.5% tolerance. These are cheap and easy to get, the only snag being that 10nF seems to be the largest value widely available, and so some paralleling is required. This is however a good deal cheaper and easier than any other way of obtaining the desired close-tolerance capacitance.

Metal-oxide resistors are used in the RIAA network and in some other critical places. This is purely to make use of their tight tolerance (1% or 2%), as tests proved, rather unexpectedly, that there was no detectable noise advantage in using them.

The recently updated RIAA specification includes what is known as the "IEC amendment". This adds a further 6dB/octave low-cut time-constant that is -3dB at 20.02Hz. It is intended to provide some discrimination against subsonic rumbles originating from record warps, etc, and in a design such as this, with a proper subsonic filter, it is rather redundant. Nonetheless the time-constant has been included, in order to keep the bottom octave of the RIAA accurate. The time-constant is *not* provided by R_3, C_3 which is no doubt what the IEC intended) but by the subsonic filter itself, a rather over-damped third-order Butterworth type designed so that its slow initial roll-off simulates the 20.02Hz time-constant, while below 16Hz the reponse drops very rapidly. Implementing the IEC roll-off by reducing C_3 is not good enough for an accurate design due to the large tolerances of electrolytic capacitors. However, the R_3, C_3 combination is arranged to roll-off lower down (-3dB at about 5Hz) to give additional subsonic attenuation.

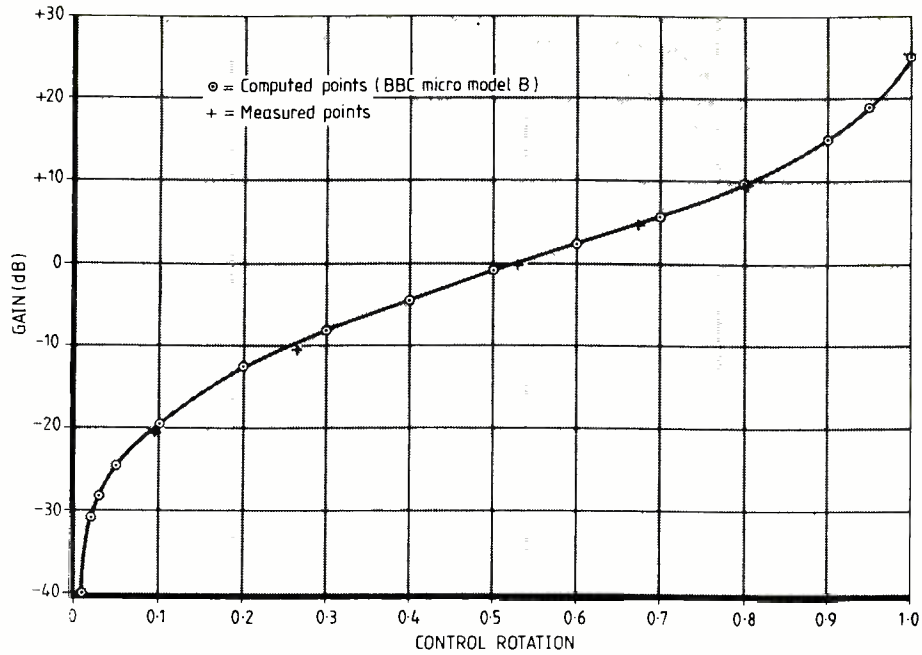


Fig. 4. Law of gain-control pot., approximately linear over main part of range.

Capacitor C_1 defines the input capacitance and provides some r.f. rejection. A compromise value was chosen, and this may be freely modified to suit particular cartridges.

The noise produced by the disc input stage alone, with its input terminated with a 1k resistor to simulate roughly a moving-magnet cartridge, is -84.5dB with reference to a 5mV r.m.s. 1kHz input (i.e. 100mV r.m.s. out) for a typical 5534A sample. The suffix A denotes selection for low noise by the manufacturer. When the 1k termination is replaced by a short circuit, the level drops to -86dB, indicating that in real life the Johnson noise generated by the cartridge resistance is significant, and so the stage is really as quiet as it is sensible to make it.

Subsonic filter

As described above, this stage not only rejects the subsonic garbage that is produced in copious amounts by even the flattest disc, but also implements the IEC roll-off. Below 16Hz the slope increases rapidly, the attenuation typically increasing by 10dB before 10Hz is reached. The filter therefore gives good protection against subsonic rumbles, that tend to peak in the 4-5Hz region.

This filter obviously affects the RIAA accuracy of the lowest octave, and so C_{12}, C_{13}, C_{14} should be good-quality components. A 10% tolerance should in practice give a deviation at 20Hz that does not exceed 0.7dB, rapidly reducing to an insignificant level at higher frequencies. The tape output is taken from the subsonic filter, with R_{12} ensuring that long capacitative cables do not cause h.f. instability. If it really is desirable to drive a 600 ohm load, then C_{15} must be increased to 220 μF to maintain the base response.

High-impedance buffer

This buffer stage is required because the following tone-control stage demands a low-impedance drive, to ensure that operating the tape monitor switch S_2 does not affect the tape-output level. If the input selector switch S_1 was set to accept an input from a medium impedance source (say 5k), and the buffer had a relatively low input impedance (say 15k), then every time the tape-monitor switch was operated there would be a step change in level due to the change of loading on the source. This is avoided in this design by making the buffer input impedance very high by conventional bootstrapping of R_{15}, R_{16} via C_{17}. This is so effective that the input impedance is defined only by R_{14}. Unlike discrete-transistor equivalents, this stage retains its good distortion performance even when fed from a high source resistance, e.g. 100k.

Tone-control stage

Purists may throw up their hands in horror at the inclusion of this, but it remains a very useful facility to have. The range of action is restricted to ±8dB at 10kHz and ±9dB at 50Hz, anything greater being out of the realm of hi-fi. The stage is based on the conventional Baxandall network with two slight differences. Firstly the network operates at a lower impedance level than is usual, to keep the noise as low as possible. The common values of 100k for the bass control and 22k for the treble control give a noise figure about 2.5dB worse. Even with the values shown, the tone stage is

www.americanradiohistory.com

about 6dB noisier than the buffer that precedes it. Both potentiometers are 10k linear, which allows all the preamp. controls to be the same value, making getting them a little easier. The low network impedance also reduces the likelihood of capacitative interchannel crosstalk. Once again, implementing it is only possible because of the 5534's ability to drive low-value loads.

Secondly, the tone-control stage incorporates a vernier balance facility. This is also designed as an active gain-control, with the same benefit of avoiding even small compromises on noise and headroom. The balance control works by varying the amount of negative feedback to the Baxandall network, and therefore some careful design is needed to ensure that the source resistance of the balance section remains substantially constant as the control is altered, or the frequency response may become uneven. Resistors R_{22}, R_{23}, R_{24} define this source resistance as 1k, which is cancelled out by R_{17} on the input side. The balance control has a range of +4.5 to -1.0dB on each channel, which is more than enough to swing the stereo image completely from side to side. If you need a greater range than this, perhaps you should consider siting your speakers properly.

Active gain-control stage

An active gain-control stage must fulfil several requirements. Firstly, the gain must be smoothly variable from maximum down to effectively zero. Secondly, the law relating control rotation and gain should be a reasonable approximation to logarithmic, for ease of use. Finally, the use of an active stage allows various methods to be used to obtain a better stereo channel balance than the usual log. pot. offers.

All the configurations shown in Fig. 2 meet the first condition, and to a large extent, the second. Figures 2(a) and 2(b) use linear controls and generate a quasi-logarithmic law by varying both the input and feedback arms of a shunt-feedback stage. The arrangement of Fig. 2(c), as used in the previous article, offers simplicity but relies entirely on the accuracy of a log. pot. While 2(a) and 2(b) avoid the tolerances inherent in the fabrication of a log. track, they also have imperfect tracking of gain, as the maximum gain in each case is fixed by the ratio of a fixed resistor R_m to the control track resistance, which is not usually tightly controlled. This leads to imbalance at high gain settings.

Peter Baxandall solved the problem very elegantly[1], by the configuration in 2(d). Here the maximum gain of the stage is set not by a fixed-resistor/track-resistance ratio, but by the ratio of the two fixed resistors R_a, R_b. A buffer is required to drive R_a from the pot. wiper, because in a practical circuit this tends to have a low value. It can be readily shown by simple algebra that the control track resistance now has no effect on the gain law, and hence the channel balance of such a system depends only on the mechanical alignment of the two halves of a dual linear pot. The resulting gain law is shown in Fig. 4, where it can be seen that a good approximation to the ideal log (i.e. linear in dB) law exists over the central and most used part of the control range.

A practical version of this is shown in Fig. 3. A_5 is a unity-gain buffer biased via R_{25}, and R_{26}, R_{27} set the maximum gain to the desired +26dB. Capacitor C_{25} ensures h.f. stability, and the output capacitor C_{26} is chosen to allow 600 ohm loads to be driven. A number of outwardly identical Radiohm 20mm dual-gang linear pots were tested in the volume control position, and it was found that channel balance was almost always within ±0.3dB over the gain range -20 to +26dB, with occasional excursions to 0.6dB. In short, this is a good way of wringing the maximum performance from inexpensive controls, and all credit must go to Mr Baxandall for the concept.

At the time of writing there is no consensus as to whether the absolute polarity of the audio signal is subjectively important. In case it is, all the preamp. inputs and outputs are in phase, as the inversion in the tone stage is reversed again by the active-gain stage.

Power supply

The power supply is completely conventional, using complementary i.c. regulators to provide ±15V. Since the total current drain (both channels) is less than 50mA, they only require small heatsinks. A toriodal mains transformer is recommended for its low external field, but it should still be placed as far as possible from the disc input end of the preamplifier. Distance is cheaper (and usually more effective) than Mu-Metal. Since the 5534 is rated up to ±20V supplies, it would be feasible to use ±18V to get the last drop of extra headroom. In my view, however, the headroom already available is ample.

Construction

The preamplifier may be built using either 5534 op-amps or the 5532 dual type. The latter are more convenient (requiring no external compensation) and usually cheaper per op-amp, but can be difficult to obtain. To compensate each 5534 for unit gain, necessary for each one, connect 15pF between pins 5 and 8. Note that the rail decoupling capacitors should be placed as close as possible to the op-amp packages – this is one case in which it really does matter, as otherwise this i.c. type is prone to h.f. oscillation that is not visible on a scope, but which results in a very poor distortion performance. It must also be borne in mind that both the 5534 and 5532 have their inputs tied together with back-to-back parallel diodes, presumably for voltage protection, and this can make fault-finding with a voltmeter very confusing.

Only 2.5% capacitors should be used in the RIAA networks if the specified accuracy is to be obtained. Resistors in Fig. 3 marked * should be metal oxide 1% or 2%, for reasons of tolerance only. Each of these resistors sets a critical parameter, such as RIAA equalization or channel balance, and no improvement, audible or otherwise, will result from using metal oxide in other positions.

Several preamp. prototypes were built on Veroboard, the two channels in separate but parallel sections. The ground was run through in a straight line from input to output. Initially the controls were connected with unscreened wire, and even this gave acceptable crosstalk figures of about -80dB at 10kHz, due to the low circuit impedances. Screening the balance and volume connections improved this to -90dB at 10kHz, which was considered adequate. It must be appreciated that the crosstalk performance depends almost entirely on keeping the two channels physically separated.

Some enthusiasts will be anxious to (a) use gold-plated connectors; (b) by-pass all electrolytics with non-polarized types; or (c) remove all coupling capacitors altogether, in the pursuit of an undefinable musicality. Options (a) and (b) are pointless and expensive, and (c) while cheap, may be dangerous to the health of your loudspeakers. Anyone wishing to dispute these points should arm themselves with objective evidence and a stamped, addressed envelope.

Specification

(Based on measurements made on three prototypes, with Sound Technology 1710A).

Moving-magnet

noise ref. 5mV r.m.s., 1kHz input	-81dB
RIAA accuracy	±0.2dB
input overload point (1kHz)	300 mV r.m.s.

Line inputs

noise ref. 100mV r.m.s. i/p	-85dB
maximum input	9V r.m.s.
maximum gain	+26dB
treble control range	±8dB
bass control range	±9dB
vernier balance control	-1dB to +4.5dB
volume control channel balance	±0.3dB
distortion (1kHz-20kHz)	0.005%
maximum output	9.5V r.m.s.

References

1. Self, D. High-Performance Preamplifier. *Wireless World*, Feb. 1979.
2. Walker, H.P. Low Noise Audio Amplifiers. *Wireless World*, May 1972, pp. 233-237.
3. Linsley-Hood, J. "Modular Preamplifier." *Wireless World*, Oct. 1982, p. 32 onwards.
4. Lipshitz, S.P. "On RIAA Equalisation Networks." *J. Audio Eng. Soc.*, June, 1979. p. 458 onwards.
5. Baxandall, P. "Audio Gain Controls." *Wireless World*, Nov. 1980, pp. 79-81.

www.americanradiohistory.com

Current dumping review—2

Current dumping is a circuit technique which claims to abolish all crossover and other distortion caused by a class B output stage. This analysis shows that in precisely this respect the performance of current dumping is notably inferior to that of a traditional amplifier of similar design.

by Michael McLoughlin

Discussion so far can be summarized by reference to Fig. 8, where V represents the distorting dumper V_{be} and its quasi-rectangular behaviour. Signal input has been ignored as it is the influence of V on E which is to be studied.

The aim is to ensure that variation of V does not affect E. If A is taken as finite this cannot be done by balancing the bridge in the usual fashion. For no change at E then implies no change at C or at B, implying change at E contrary to hypothesis. What is required is for the bridge to be a little off balance, so that when E remains constant a small amount of V is fed back to the amplifier: enough to shift B appropriately. Clearly then the small bridge unbalance required is inversely proportional to the gain A. Algebra will handle the details, and dumper distortion will totally cancel, however V behaves.

As mentioned, taking A as infinite leads to destruction of the system. The bridge would require to be balanced as normal, because A now requires no input voltage. Whence if E is not varying with V the negative input of A might as well be connected to E instead of to C. Then Z_1 and Z_2 can be removed, and Z_4 replaced by a wire.

Previous discussion was based on a floating signal source, which is not attractive. Further, the floating "zero volts" rail required frequent corrections to the algebra. Divan and Ghate (WW April 1977) remove these irritations, and bring the theory to a new level with the circuit of Fig. 9. They include Z_{in} together with the gain-setting element Z_f hinted at by Walker, and take A as finite. Their balance condition (6) is derived in two lines in Fig. 9, and contains all earlier results.

Invalidity

Murmurs have been heard that much of this debate is invalid. Suppose that the output current through Z_L in Fig. 9 is sinusoidal. Then the current marked i through Z_4 supplies most of it, but it is switched off during crossover. Meanwhile I−i flowing through Z_3 supplies what is wanting. Then both of these currents depart dramatically from the sinusoidal form.

Now the interest of this analysis lies largely in the study of the very successful Quad 405 amplifier design that uses the technique. But in that amplifier Z_2 is a capacitor and Z_4 an inductor. When currents and voltages depart from the sinusoidal it is impossible to attach impedance values to these components, and the symbols used above for such quantities have no meaning. Take the case of Fig. 10, where a 'square' voltage wave is applied to a capacitor and series resistor. The ratio V/I wanders through most values from zero to infinity throughout the cycle, and there is no constancy about it at all. In these circumstances one may certainly not note the current through C, and divide by jωC to obtain the voltage across this component. Fig. 10 certainly presents an extreme case, but if Z_2 is a capacitor it is just the case of Fig. 9. A quasi-rectangular voltage is applied to this component, and the current is to be derived by multiplying by jωC!

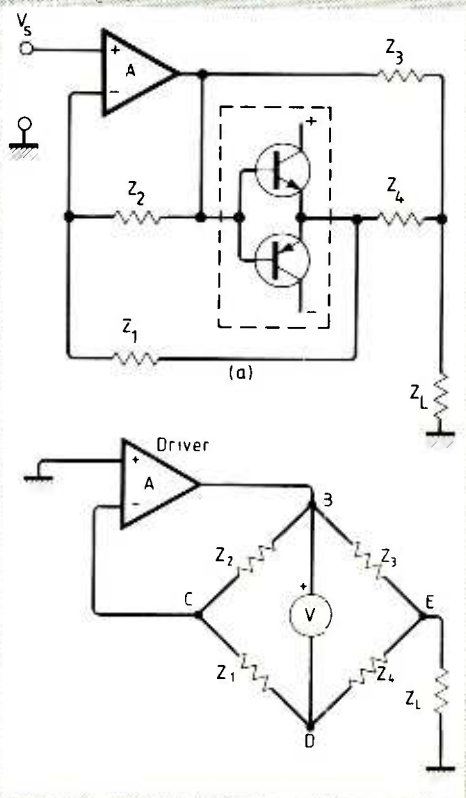
If V in Fig. 10 is a sinusoid then the current I has that form also. If we agree to make comparisons with a certain time delay between these two variables, then a constant of proportionality which does not vary with time will again emerge. And the complex number analysis has been developed to mechanize the accounting. And it would be valid in this circuit to resolve V into sinusoids, use complex numbers on each separately to deduce the consequent I, and add the results. Of course the results would be at different frequencies. But this does depend on the circuit being composed of only linear components, where the output due to a sum of inputs is sure to be the sum of what each would produce separately.

This might be tried in Fig. 9, by

Current dumping

Basic current dumping circuit Fig. 8 (a) may be redrawn as a bridge (b), with the distorting dumper V_{be} modelled as a voltage generator of similar behaviour. Signal can be neglected: it is this voltage generator that can produce no output at E.

Hypothesis: E does not vary when V does. Then it is useless to balance the bridge as normal for no change at E then implies none at C, or at B, resulting in change at E contrary to hypothesis. Slight imbalance at C is required instead. Then if V increases E remains unaltered, but there is a slight fall at C: enough to lift B sufficiently to ensure E is unaffected. The imbalance required is both slight and critical, and the arrangement is very sensitive to tolerance errors.



www.americanradiohistory.com

resolving the currents i and I–i into sinuoids, and discussing each component separately. But Fig. 9 does not show a network composed of linear elements: base-emitter junctions are non-linear in the extreme. This route is barred.

One example of the many possible consequences of reckless resolution into sinusoids is provided by the ordinary a.m. detector. Suppose that such a circuit is supplied with a carrier modulated by a tone. The output is of course the tone, plus a d.c. level. But now resolve the input into sinusoids: the carrier plus two sidebands. Taken separately each of these would produce only a d.c. levels and when added they yield only a d.c. level: the tone has vanished. Conclusion: no detector detects!

Validity

Such criticisms do appear to apply to most of the previous discussion, including of course our own treatment in Fig. 9. However the bridge model of Fig. 8 escapes untouched. Here the troublesome non-linear dumpers have been replaced by a voltage generator, and in determining whether a circuit is composed of linear elements the generators do not have to pass any tests. (Detailed information about the behaviour with time of this generator will be required later.)

Could this trick for turning a non-linear into a linear circuit be applied elsewhere, perhaps in the a.m. detector mentioned above? It can, provided that sufficient information is available about the non-linear voltage V. In the case of the detector the diode must be replaced by V, and when V has to be specified it will be given audio elements suitable for producing the correct output, now that the r.f. cannot yield it. The procedure is valid enough, but in this case scarcely attractive.

Advance to Fig. 9 again. Replace the dumpers by transistors of constant current gain but zero V_{be}, in series with a voltage generator to be inserted at G. These odd transistors are linear elements: their emitter current in response to a sum of base currents is just the addition of what each would produce separately. And the V_{be} generator may produce such voltage as it sees fit, while the signal at A varies, without violating the linear character now

Table 1. Discontinuity in sinusoidal output E at crossover. Theory provides these figures when tolerances are taken into account. Case 1 offers two transitions per crossover, and the figure in the text has been doubled, as e=0.2 now. Using closer tolerance components would benefit the first two cases equally. Adding bias components would benefit all three cases equally.

Organisation	V pk-pk	Notes
1. As supplied	7.0mV	∝E and ∝f
2. Resistive bridge	0.6mV	at all E and f
3. Traditional amplifier	0.15mV	at all E and f

Transitions at crossover: Quad 405
e=0.2 f=13.2kHz E=1V r.m.s.

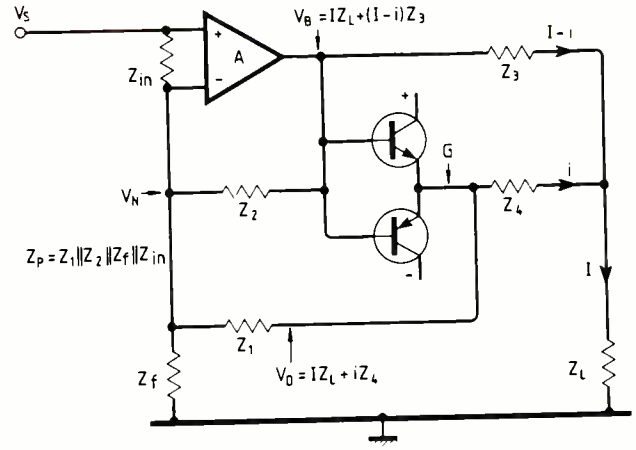


Fig. 9. In Divan and Ghate model for current dumping V_B/A must exist between the input terminals of A. So V_N may be derived from V_S. The result is equated below to V_N, as derived by Millman's theorem (proved in Fig. 6):

$$V_s - \frac{IZ_L+(I-i)Z_3}{A} = Z_p\left[\frac{IZ_L+(I-i)Z_3}{Z_2} + \frac{IZ_L+iZ_4}{Z_1} + \frac{V_s}{Z_{in}}\right]$$

This is a linear bond between V_s and I if the terms in i balance out:

$$\frac{Z_4}{Z_1} = \frac{Z_3}{Z_2} + \frac{Z_3}{AZ_p} \qquad (6)$$

possessed by the network. Naturally we shall oblige G to follow the real V_{be}. The network is now linear, but has two input signals.

When deprived of their V_{be} the two dumpers together make a single linear element. Admittedly a slight violation of linearity will occur on passage from one dumper to the other, because their current gains will not be equal. Apart from this detail, the model now offers a rigorous treatment of the bulky non-sinusoidal currents and voltages in the reactive bridge components. And on a second reading it will be possible to see that this assymetry must degrade a little further the result in the first line of Table 1, thus strengthening our conclusion there.

The two inputs at V_s and G in Fig. 9 may now be considered as sums of sinusoids, and the influence of these on output may be anlysed one frequency at a time. Or V_s and G could be considered separately. And handling one frequency at a time the usual complex number analysis may be employed, with the final output counted as the sum of the separate outputs produced by all these components. Using these tricks a valid proof of (6) can now be given, after the style of what follows.

Quad 405 circuit

The full circuit may be inspected in the operating manual, or in Walker's article Fig. 11 offers his simplified version, with Z_1 to Z_4 clearly marked, and values are attached.

Recall that the generator V in Fig. 8(a) really represents the two complementary dumpers. Their emitters are connected to D and bases to B. So Walker identifies the circuit of Fig. 11 with that of Fig. 8(a). But there is a difficulty. Not only has an extra transistor Tr_2 appeared, but Z_1 and Z_2 are connected to opposite ends of it. Now dumper V_{be} variation will inject current

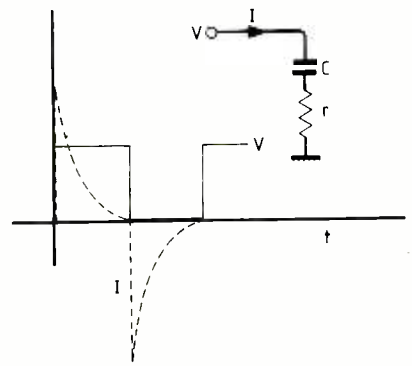


Fig. 10. Current when a rectangular wave voltage is applied to a capacitor and series resistor.

via Z_1 into Tr_2 emitter, and if the driver gain is large this current might just as well be considered as injected into the collector circuit directly. To effect this transfer is just the role of a transistor. Thus if the input signal in Fig. 11 is set at zero, then from an a.c. viewpoint Z_1 can be considered as connected directly to the collector, to identify with the layout of Fig. 8.

But if minimum figures are taken for the gains of the transistors in the driver, its input impedance is about 50kΩ, and during crossover its voltage gain is only about 77. Thus at 1kHz the capacitor C presents an impedance to Tr_2 collector of $Z_C/77$ or 17kΩ. The collector will feed such a load without difficulty. The current is provided by Z_1 = 500Ω, and is injected into the emitter with little difficulty. But that resistor could not be expected to feed 17kΩ without change: Z_1 may not really be considered to be connected to the collector, and Fig. 8 is not an accurate model for the real circuit of Fig. 11.

Vanderkooy and Lipshitz handle the difficulty in just the opposite way, by considering Z_2 to be disconnected from the collector and joined instead to the emitter. Transistor Tr_2 becomes part of the driver amplifier, and the circuit again identifies with that of Fig. 8(a). From the figures

www.americanradiohistory.com

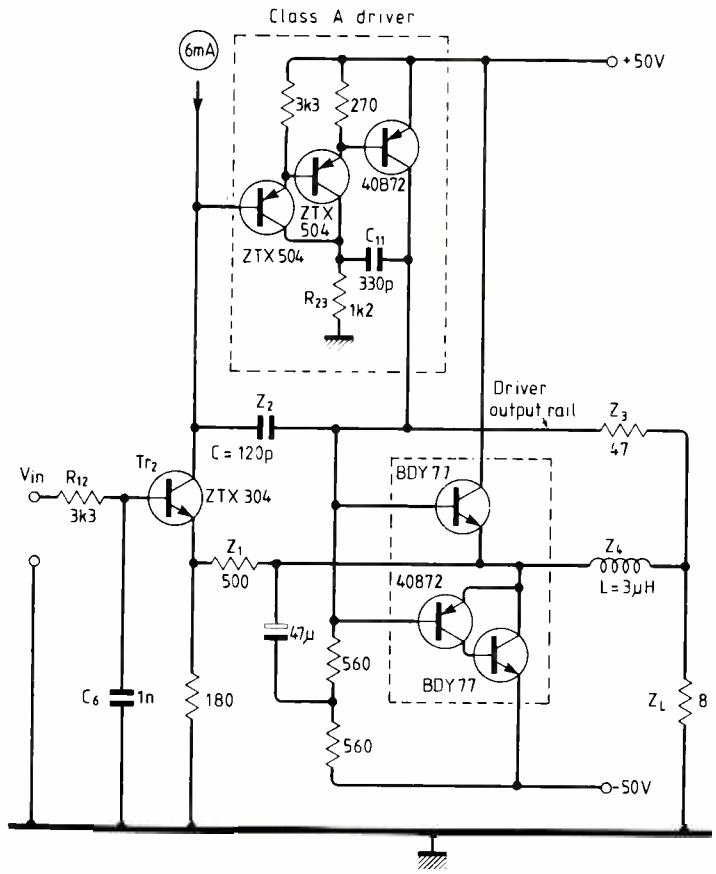


Fig. 11. Walker's simplified circuit of the Quad 405 amplifier, omitting current limiting and h.f. trim components. I have further omitted the LM301A op-amp that provides V_{in}. (It operates in class A, is not part of the current dumping circuitry, and receives only a d.c. feedback – not shown – from Z_L to centre the working point of the dumpers) Minimum h_{FE} for a BDY77 is 40; for the other transistors shown it is 50.

Fig. 12. In this current dumping model A, B, C, D, V denote voltages, small letters admittances.

DEFINITIONS

k: dumper $i_b = ki_e$

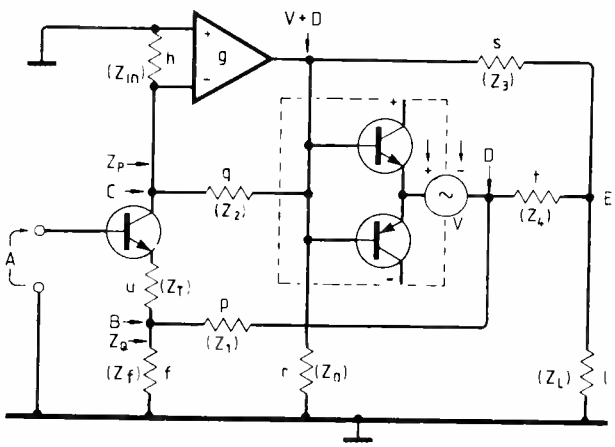
$b = q + r + s$

$m = l + s + t$

$n = f + p + u : \frac{u}{n} = \lambda \approx 1$

$g' = g - q$

$Z_p = \frac{1}{h+q}; Z_Q = \frac{1}{n}$



CONSTRAINTS

$s(V+D-E)+q(V+D-C)+r(V+D)+k[t(D-E)+p(D-B)]=-gC$

(1) $-(s+kt)E=-bV-[b+k(t+p)]D+kpB-g'C : n(s+t)(h+q)$

(2) $(s+t)D=mE-sV;\ nB=uA+pD : (s+t)$

(3) $n(s+t)B=u(s+t)A+pmE-psV;\ (h+q)C=uB-uA+qV+qD : n(s+t)$

(4) $n(h+q)(s+t)C=-u(s+t)(f+p)A+(nqt-psu)V+m(pu+qn)E$

ARGUMENT

Write $wE=xA+yV$ where (7)

$w=(h+q)[mn(-s-kt+b+k(t+p))-kppm+nl(s+kt)]+g'm(pu+qn)$

$=(h+q)[mn(q+r)+kpm(f+u)+nl(s+kt)]+g'm(pu+qn)$

$x=u(s+t)[kp(h+q)+g'(f+p)]$

$y=-bn(s+t)(h+q)+[b+k(t+p)]n(h+q)s-kp(h+q)ps+g'(psu-nqt)$

RESULT

$y=0 \Rightarrow g'(psu-nqt)=(h+q)[bnt-kns(t+p)+kpps] : \div g'stn$

$$\lambda \cdot \frac{Z_4}{Z_1} = \frac{Z_3}{Z_2} + \frac{1}{g'Z_p}\left[1+Z_3\left(\frac{1}{Z_2}+\frac{1}{Z_Q}\right)-k\left\{1+\frac{Z_4}{Z_1}\left(1-\frac{Z_Q}{Z_1}\right)\right\}\right] \quad (8)$$

Approximate admittances at 1kHz (moduli in mhos)

$p=10^{-3},\ q=10^{-6},\ r=10^{-3},\ s=10^{-2},\ t=50,\ l=0.1,\ f=10^{-2}, u=3\times10^{-2},$
$h=2\times10^{-5},\ g=2.\ 0<k<1/40.$

just given for the driver of Fig. 11 it is clear that above 1kHz it works as an operational amplifier, ensuring that most of the current supplied by Tr_2 is drawn away through C, while leaving only a small amount to work the driver itself. Now as the current gain of Tr_2 from emitter to collector is unity, C could indeed syphon off this current with similar effect at the emitter instead.

But this alteration does obscure an important factor. In Fig. 11 the element Z_1 is marked as 500Ω, but in fact any current due to dumper V variation flowing into Tr_2 emitter is also affected by the emitter input impedance found there. Owing to the presence of R_{12} this may be as high as 3.3k/50 + 25/6 = 70Ω, causing a 14% increase in the effective value of Z_1. If now Z_2 is connected instead to the emitter and there syphons off its current from that flowing into the driver, then scarcely any of the current supplied through Z_1 remains to flow into the emitter. Not much impeding voltage arises, and the 14% adjustment required in the value of Z_1 disappears. If a bridge is to be balanced then a 14% adjustment in the value of one arm is serious, and Z_2 may not be reconnected as proposed in any accurate model of Fig. 11.

It seems possible that Z_1 and Z_2 were initially connected to the same point of Tr_2, but were later separated as part of the h.f. trimming programme evident in the full circuit.

Quad 405 model

Fig. 12 offers a model for Fig. 11. The driver has been reduced to linearity by its specification in terms of mutual conductance. The dumpers are so reduced by thinking of them as transistors of equal current gain but zero V_{be}, in series with a generator to simulate the latter. The driver is equipped with input impedance Z_{in} and output impedance Z_o. Gain-setting element Z_f appears. Delivery of feedback to both ends of Tr_2 is properly represented. Finally Z_T is in series with Tr_2 emitter to stand for the input impedance found there.

The circuit may now be analysed in terms of the two input voltages A and V. Because the components are all linear these may be treated separately, and as sums of sines. Thus complex number analysis is valid. But the twin menaces of this sort of analysis are suffices and denominators. It has been possible to avoid both by giving each impedance a second unbracketed symbol to represent its admittance.

The definitions section of Fig. 12 starts by defining k to account for dumper current gain, and there follow names for concatenations of symbols that will arise. About half the remainder may be omitted at first reading, and the new balance condition (8) can be attained quite quickly.

Constraints

Solving the circuit of Fig. 12 consists in obtaining the relationship between the three voltages A, V and E. To build relationships it has been necessary to introduce voltages B, C and D, so these are to be eliminated.

Observing that the current flowing away

www.americanradiohistory.com

from the driver is equal to what it provides, then line 1 collects the variables (capitals) in this constraint, using the shorthand defined. Line 2 starts by defining E, using Millman's theorem if sV is added to both sides.

From an a.c. viewpoint the upper end of u is at potential A, and so later in line 2 Millman's theorem is used to define B. If this equation is multiplied by the factor on its right it may be rewritten as (3) by using (2).

This captures D and B in terms of desired variables. It is just a little harder to do this for C. A constraint is given for it later in line 3. If the two terms in q on the right are transferred to the left hand side, the equation is justified as a statement that the current flowing away from C is just what is delivered there by Tr_2. Multiply the equation in its present form by n(s + t) as suggested on its right. It should be possible to arrive at line 4 without a pencil, using (2) and (3) to remove D and B. Collecting first the terms in A yields a coefficient uu(s + t) − un(s + t), equal to what is written. Collecting the terms in E out of B and D is easier. And the coefficient for V is simpler than expected because two terms nqs have cancelled.

Argument

The peak of difficulty is already passed, and (8) is within reach. Focus on line 1 of constraints. If the equations at the start of the next three lines were used to remove D, B and C from line 1, a gigantic equation would result. But it would only contain the desired variables E, A and V. So it would have the form of (7). If y = 0 then certainly E and A are bound into proportionality, and the sinusoid V has no effect on E, leaving it free from distortion.

You are therefore dispensed from pursuing w and x in (7): it suffices to study y alone. Now (7) is to be considered as derived from line 1 after first multiplying that line by the factor noted on its right. This suffices to prevent the generation of any fractions. So multiply line 1 as stated, and collect on its right hand side the terms in V only, including those V found when D, B and C are substituted. Hopefully this will give y as stated.

Balance equation

First note that two terms bns (h + q) cancel out in y. Now write the result line. Then divide as stated, remembering u/n = λ. But write the result in terms of impedances rather than admittances, and (8) will appear. If this holds then y = 0 in (7), and the distorting V does not influence the output.

Relation to other balances

Equation 8 now provides the balance condition for the Quad 405. It includes the driver output impedance Z_o, and the double delivery of feedback is studied. The emitter input impedance of Tr_2 is included, and the balance is altered by the new factor λ on that account.

Suppose first that this emitter input impedance is zero (λ = 1 and Z_Q = 0). Then if Z_o is also excluded by setting it infinite, (8) reduces to the balance condition of Vanderkooy and Lipshitz. But if Z_o tends to zero while g becomes large, so that gZ_o = A, the driver has become a voltage amplifier. And then (8) takes the form of (6), though Z_P is not the same because of the isolating effects of Tr_2. Of course, setting g infinite reduces (8) to the basic $Z_4/Z_1 = Z_3/Z_2$.

But none of these things are true when λ is taken into account. If the input transistor has its minimum gain of 50, then as suggested earlier Z_T = 70Ω, and so λ = 0.65. Inserting this new factor disturbs all previous balance conditions. The gain of Tr_2 may rise to 300, yielding Z_T = 15.2Ω and λ = 0.90, which is still serious. It appears that the balance of the bridge is critically dependent on the gain of the particular transistor inserted at Tr_2.

Listed below (8) are approximate values, and it is clear that Z_3/Z_2 can be dismissed from the square bracket of (8). And the fractions that remain fall by about an order of magnitude a time: 1, Z_3/Z_o, k, Z_4/Z_1. It follows that for all attainable purposes the balance condition simplifies to

$$\lambda\cdot\frac{Z_4}{Z_1}=\frac{Z_3}{Z_2}+\frac{1}{gZ_p}\left[1-k+\frac{Z_3}{Z_0}\right]. \qquad (9)$$

Bridge balance

Many balance conditions have been published, but no-one has yet inserted the four Z values of Fig. 11 into their result. This may be because the simple condition $Z_4/Z_1 = Z_3/Z_2$ reduces to $L = R_1R_3C$, and it shows a 6% unbalance.

To find figures for g and Z_P in (9), consider the two 560Ω resistors in Fig. 11. These provide a nominal 50mA current sink for the dumper bases, and around crossover this current is provided by the driver. Now 1mV applied to the driver input mostly reaches the 40872 base, causing the usual 4% alteration in its collector current. This change is 2mA, which shows that the driver mutual conductance g is around 2 amps/volt. Assume minimum transistor gains, and follow the electrode impedances associated with 50mA current output back to the input terminal: the impedance there is just over 50kΩ. This is a fair figure for Z_P also, because even at 10kHz the reactance of Z_2 is still 133kΩ. So gZ_P in (9) is 10^5, or more if the transistor gains exceed minimum.

Take λ = 1 for the moment, and suppose f is the standard frequency of 13.2kHz at which Vanderkooy and Lipshitz run their tests: then the three terms of (9) work out in millionths as 498j, 468j, and 10 or less. The first two terms are imaginary and the third is real. Then the best that can be done is to balance off the first two terms by $Z_4/Z_1 = Z_3/Z_2$, and ensure that the third term is small. The designers appear to have done this. But there is still that unexplained 6% unbalance between the large terms.

But the two imaginary terms of (9) should really be balanced off by

$$\lambda\cdot\frac{Z_4}{Z_1}=\frac{Z_3}{Z_2}. \qquad (10)$$

Now the median gain of Tr_2 is 175, so its emitter input resistance may be 3300/175 + 25/6 = 23Ω, yielding λ = 0.852. The three terms in (9) now work out in millionths as 424j, 468j, and 10 or less. The first term is now some 10% down on the second, and the Quad 405 bridge appears to be out of balance by this amount in the opposite direction.

An easy way to correct this would be to reduce Z_1 by the same factor 424/468, which could be done by connecting in parallel a 4.8kΩ resistor. Now Vanderkooy and Lipshitz did vary the resistance of Z_1 to achieve minimum crossover distortion, and they demonstrate their results with oscillograms. Their finding: for best balance Z_1 requires a resistor in parallel of "about 5k". This confirms that there is a systematic unbalance of some 10% in the Quad 405 bridge, though the precise figure varies sharply with the gain of Tr_2.

Conclusion on circuit design

Clearly the dv/dt limiter R_{12} with C_6 that is causing unpredictable λ must be placed earlier in the circuit and not here. The low impedance source driving Tr_2 must be allowed direct access to this transistor, and resistors must be kept out of this area. Another way of making the same point is to observe that extra input currents flow during crossover, and the input impedance of a current dumping circuit varies wildly as a result.

There are only three terms in (9), and the third is by far the smallest at typical frequencies. If 5% components are used, as in the 405, then each of the first two terms can vary 10% by tolerance errors. Then one side of (9) may exceed the other by 20% on that account. Then it is useless to seek circuit sophistication to eliminate the unbalancing effects of k (dumper base current) in (9): any such effects are orders of magnitude less than tolerance errors. Although T. Hevreng has solved this problem in a way that must command admiration (May 1979), such a solution is not of practical utility. The correct conclusion is the inverse: k affects the balance of (9) so little that it is not worth using Darlington type dumpers to reduce it. And the Quad 405 designers were right not to bother. Equally, H. S. Malvar is not really practical in enquring after say 10% variations in g during the signal cycle.

Minor effects

Vanderkooy and Lipshitz point to the upper 560Ω resistor in Fig. 11 as an unbalancing element. It can be modelled as connected from V+D to D in Fig. 12. And a mesh-star tranformation with Z_3 and Z_4 shows that the effect is to reduce both these values by 8%, leaving unaltered the balance of the first two terms in (9). The lower 560Ω is effectively connected from D to ground, and a similar transformation with the new value of Z_4 and the load shows that this time Z_4 is effectively reduced about 1½%, but without other compensations in (9). Thus these resistors do not affect the possibility of bridge balance.

These two authors also point to the unbalancing effect of the compensation

www.americanradiohistory.com

components R_{23} and C_{11} in Fig. 11. These load the driver output a little, but they can be included in the symbol Z_o of Fig. 12, so that the bridge can still be balanced. Their effect on the driver input can be seen as follows. Suppose the driver output rail in Fig. 11 is falling at 10^6V/s: then 0.33mA flows out from C_{11}, causing the top of R_{23} to fall 0.4V. If the first transistor in the driver has a collector impedance of 100kΩ when its base current is held constant, then 4μA will be drawn through it. An identical disturbance to its current would be produced by increasing its base current by 0.1μA or less. Meanwhile, in response to the driver output ramp, Z_2 is delivering 0.12mA, which is being fed to it from Tr_2. Then 0.1% increase in the value of Z_2 would increase the current in it by 0.1μA, which would come from the driver input terminal. Conclusion: the disturbance to the input can be well modelled by imagining Z_2 is increased by up to 0.1%. Compared with the tolerance error of that component this is a trivial correction.

An equivalent amplifier

Because reactive components have been used the first two terms of (9) are imaginary, and so the best that can be done to balance it is to insist on (10). But this means psu = qnt. So no V appears in the equation for C in line 4 of Fig. 12. Voltage C represents the mix of both signal and feedback, and it controls the output completely. And the equation for it is now

$$(h+q)C=-\lambda(f+p)A+\frac{m}{s+t}(\lambda p+q)E.$$

Provided that C is bound to A and E in this way any method of deriving it may be used, and will produce the same output voltage as before. For example, disconnect q in Fig. 12 and connect it in parallel with h. Then C will arise as just specified if a current equal to the expression on the right of this equation is injected into Tr_2 emitter. So replace f and p in Fig. 12 by f′ and p′, but connect the right hand side of the latter directly to E. The upper end of u may be considered to have potential. A. Then by studying only the components now connected to B it is easy to verify that the current entering Tr_2 emitter is correct if

$$p'+f'=p+f$$
$$p'=(p+q/\lambda)m/(s+t).$$

If these values are fitted the amplifier will have the same performance as the current dumping circuit. Further, Z_4 can now be shorted and its influence absorbed into V, about which we have never had to be specific. The amplifier is now shorn of its current dumping components Z_2 and Z_4, but with three others adjusted it will have identical performance.

These modifications alter the output load slightly, but that has never been a factor. Also a 520Ω load was removed from D in Fig. 12. A mesh-star transformation between this, Z_4 and Z_L shows that this removal is equivalent to increasing Z_4 by 1½%. Reduce it again and operation is as before. And the new Z_4 can be absorbed into V as previously.

The problem

In 1975 a new type of audio amplifier was announced, called the "current dumping" amplifier. Described in the US patent as "distortion-free", more than 60,000 units have now been sold, with retail value exceeding £15 million, and the design has won a Queen's Award to Industry. Yet in the lively discussion that resulted in this journal, one group insists that the amplifier works by feedforward, another school disagrees and says it uses feedback, whilst a third party maintains it is all a grave error: the performance is actually *worse* than that of a traditional circuit.

Has then something useful been invented, and if so exactly what is it?

A solution

Part 1, September issue, explained and simplified previous contributions in this journal. The feedforward and feedback explanations are not rivals, but valid alternatives. The bridge model developed was shown to be of greater power than the others.

Part 2 now explains the central idea of the invention, with an improved statement for the balance that must hold between the four key components in the bridge. The third party in the debate appears to be correct: the idea is spoilt by errors due to the tolerances of the components. When these are allowed for, the insertion of the current dumping components actually *degrades* the amplifier performance. Fig. 8 explains the central idea at stake.

Infertility?

Current dumping then is doing nothing useful, because of the particular bridge balance chosen. Observations of this tenor by Halliday, Olsson and Bennett were reported toward the end of Part 1, and this view is now supported by the model of Fig. 12.

Such algebra invites an explanation. The trouble seems to start with (9). Faced with that requirement a designer unsure of his g may make it large and forget it, relying on (10). And with the Quad 405 the imaginary character of the first two terms in (9) compels the designer to resort to (10).

Now redefine Z_1 in (9) as $Z_1' = Z_1/\lambda$. This means that we propose to account for the 23Ω or so impedance found at the emitter of Tr_2 by thinking of Z_1 as altered slightly to include its resisting effects. The circuit now identifies well with that of Fig. 8 with Z_1' fitted there. Now multiply (9) by Z_1'/Z_3 to yield the alternative form.

$$\frac{Z_4}{Z_3}-\frac{Z_1'}{Z_2}=\frac{Z_1'}{gZ_pZ_3}\left[1-k+\frac{Z_3}{Z_0}\right]. \qquad (11)$$

Earlier we expected the bridge ratios in Fig. 8 to be slightly out of balance if the effect of V on E was to cancel, and (11) establishes the required difference. And this difference was expected to be inversely proportional to driver gain, as it is here.

But the designers have decided to neglect the gain term, found on the right of (11), and instead have set these bridge ratios equal by (10). But the entire purpose of current dumping is to define correctly the small amount by which the two bridge ratios need to be out of balance if the effects of V are to cancel. The idea is destroyed by any implementation that proposes to ignore the gain term in (11) and set these fractions equal. Such a move discards the essence of the dumping technique. And as shown above it is then possible to alter the amplifier into a conventional structure of identical performance.

Tolerances

The above criticism was based on the designer's decision to rely on (10). But further difficulties now arise, because the components he specifies to do this will not have their nominal values, but (in the Quad 405) may each be 5% out. This issue has been treated by T. C. Stancliffe (November 1976.)

The analysis in Fig. 12 will yield an accurate assessment of the effect of tolerances. Equation 8 there will not now balance exactly, but it may be made to do so with the actual components used if the left hand side is multiplied by (1 − e). We shall made no capital out of λ as a simple design improvement can remove this factor. Then e can reach 0.2 in magnitude. Prefacing the equation with (1 − e) is equivalent to asserting it with an extra leading term $-e\lambda Z_4/Z_1 = -e\lambda p/t$ instead. Then the previous equation can be asserted, with an extra leading term $-e\lambda pg'sn = -epg'su$. The previous line for y remains valid, but y is clearly now epg′su. Now multiply constraint line 1 by the factor on its right, do the elimination and verify that x in (7) is correctly stated. To verify the expression given for w, note that the last term in its first square bracket will be needed to reconcile the first term there. Examine w and x in the light of the approximate admittances listed. Dismiss the entire square bracket in w by writing out just its largest products

$$h[tu(r + kp + kl)].$$

The last of these is the largest, but it is many thousand times smaller than the last term of w, approximated by

$$w=gmpu \quad x=gu(s+t)(f+p) \quad y=epgsu.$$

Actually if all its products are multiplied out (7) contians initially 284 terms. But cancel gu in the expressions just given, and that equation reduces with great accuracy to

$$mpE=(s+t)(f+p)A+epsV.$$

The contribution to E from A may now be studied. As may be readily explained from Fig. 12 if V is held constant, there is a gain of $1 + Z_1/Z_f$, followed by an output impedance $Z_3//Z_4$.

Tolerance unbalance

Of greater interest here is the contribution to E from V:

www.americanradiohistory.com

$$E=\frac{es}{m}V\approx\frac{es}{t}V\approx e\frac{Z_4}{Z_3}V. \qquad (12)$$

This strikingly simple expression can be explained from the elementary model of Fig. 8. Consider the error in equation 8 as concentrated in Z_4: the value fitted is too large by a fraction e, because balance is achieved when (8) is multiplied by (1-e). Thus in Fig. 8 instead of the correct Z_4 the value is a fraction e larger. Once V is fixed, potentials B and D are in the merciless grip of the amplifier there. And as Z_4 is small, moving the tap at E off the balance point by eZ_4 yeilds (12).

Consider first the easy case where all components are resistive. Now V passes in almost rectangular fashion between −0.7 and 0.7V, the transition occuring during the length of each crossover. As the factors in (12) are real the distortion E given there will have the same waveform. Take e at its maximum value of 0.2 or so. Take Z_3 = 47Ω and Z_4 = 0.1Ω: the amplitude of the rectangular distortion contributed to E is given by (12) as 0.6 mV pk-pk.

Now suppose that Z_4 is inductive. As the square bracket term in (8) is small, errors in the others will dominate and e will still be real. Then it is legitimate to regard E in (12) as derived by forcing a current eV/Z_3 through this inductor, where V is a sinusoidal component of the distortion voltage. But the inductor is a linear compoent, so the various sinusoidal currents can be recomposed into a current eV/Z_3, where V now represents the full quasi-rectangular distortion voltage waveform. If L is an inductor and v is the rate of change of V this produces $E = Lev/Z_3$.

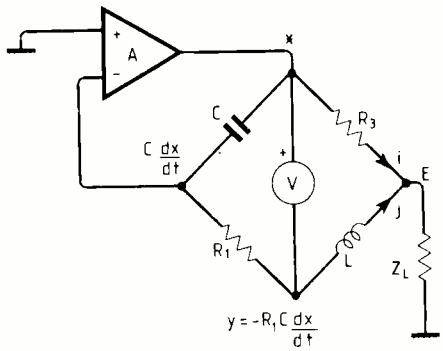
To obtain a figure for v suppose that at E the signal output is $A\sin\omega t$: then near upward crossover its slew rate is $A\omega$. To maintain this during crossover V + D has to slew an extra Z_3/Z_L times as fast (where Z_L is the load and does not refer to the inductor.) So V itself has to slew at $A\omega Z_3/Z_L$. This provides the figure for v above, yielding distortion

$$E = eA\omega L/Z_L \qquad (13)$$

constant during crossover but zero elsewhere.

Optional calculus

Calculus supports these manoevres. The argument is sketched in Fig. 13, and as investigation is concentrated on bridge unbalance the gain A has been taken as infinite. Signal has been set at zero and only the effect of V is studied. If the volts at the upper bridge vertex are x then the current through C is as stated, whence the volts at the lower vertex may be written. The two voltages must differ by V, yielding the constraint given. With the forcing function shown for V this is an easy specimen of its kind, and the full solution is sketched. As V passes the point A then x follows the broken curve shown. This may be accurately specified by saying that at A the voltage x falls by m/n, but the exponential columns shown at the origin are added back to x. At D the voltage may be said to make the same jump upward, and then to suffer the subtraction of the same columns to yield a curved transition. And y is as



Constraint:

$$\frac{dx}{dt}+nx=nV, \text{ where } n=\frac{1}{R_1C}=\frac{1}{T}$$

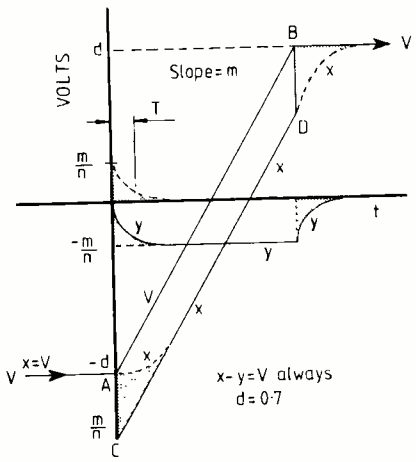


Fig. 13. With the forcing function V of slope m as drawn, x and y develop as shown. The volts y are in effect a pulse of amplitude −m/n constant during crossover but zero otherwise, as the time constant $T=R_1C\approx0.06\mu s$ only.

shown: a rectangular pulse lasting for the crossover but modified briefly at each end by the same set of exponential columns.

Rewrite (8) with $Z_1=Z_1/\lambda$ in place, to the exclusion of Z_1 and λ (the final terms in the square bracket are frivolous and may be ignored.) Now suppose the error is concentrated in Z_1'.Because for balance this equation had to be multiplied by 1 −e it follows that Z_1' is just a fraction e too small. In terms of Fig. 13 the resistor R_1 after being set at Z_1/λ turns out to have a tolerance error making it a fraction e too small.

Now suppose the change in output volts E in Fig. 12 which results from a change in V is zero. Then

$$\frac{d}{dt}(i+j)=\frac{dx}{dt}\left[\frac{1}{R_3}-\frac{R_1C}{L}\right].$$

If $R_1 = L/R_3C$ as before then i + j is constant, consistent with zero change in E, and the problem is solved. But now change R_1 to 1 − e times this expression. Examine the way in which the volts y were originally established: an additional −ey volts now appears at the lower vertex of the bridge, transmitted to $Z_L//R_3$ with short time constant L/R = 0.4μs. Appeal to the sketch of y: the resultant output E is a rectangular pulse of amplitude em/n for the duration of crossover. Insert for m the slew rate v derived earlier, and (13) follows. It is true that the new volts y do alter slightly the constraint given, but this is a second order effect.

Programmed model

If Z_4 in Fig. 11 is to be recognised from the start as an inductor L, then a fourth model of current dumping naturally arises. Suppose the output volts at the load are coasting steadily upward to zero from below. Then a steady voltage exists across L, with the left hand side positive. When the lower dumper goes off, the current in L has reached zero and it stays zero. There is no final spectacular rate of change to generate a transient, and all that happens is that the steady voltage just mentioned suddenly collapses. This provides the negative-going steady voltage pulse just discovered, which is applied to Z_1 and the resultant steady current integrated into a rising voltage ramp on the right of Z_2. The simplest algebra shows that if $L = R_1R_3C$ the resultant current ramp through Z_3 = R_3 maintains the rate of ramp of amplifier output voltage identical with its value before the lower dumper turned off.

We are left with a picture of current dumping where as crossover approaches L is programmed with a steady voltage measuring the output ramp rate. When the dumper stops conducting this programmed voltage collapses, duly executing the measures required to hold output ramp rate unaltered.

In more abstract terms L differentiates the dumper current and C recovers it by integration, together with a negative sign. As a result Z_3 passes a current equal and opposite to any sudden change in dumper current. Vanderkooy and Lipshitz make some observations on L in their article on feedforward error correction* in which they produce oscillograms to show that while a good inductor causes no trouble, an inductor wound with thick wire on a narrow former causes sharp distortion spikes during crossover, Fig. 10. The proposed explanation is that eddy currents are at work in the inductor. You might doubt whether the gentle usage just explained is apprpriate to produce such transients, and the oscillogram does resemble their Fig. 9(b), showing what happens when the bridge is unbalanced. But if this assertion is confirmed it would be a reason to expect still worse results in the first line of Table 1, reinforcing the conclusions below.

Test case

In their WW article Vanderkooy and Lipshitz provide oscillograms of crossover distortion for A = 1.4V at f = 13.2kHz with Z_L = 10Ω. When the bridge was unbalanced by reducing Z_1 by an unspecified amount, rectangular distortion pulses did indeed appear for the duration of crossover. They observed best balance when Z_1 was reduced 10%, implying an e = −0.1 for their amplifier when Z_1 is restored to its original value. Then according to (13) there should be a rectangular pulse of just 3½mV height lasting for the duration of crossover. The oscillograms

*Feedforward error correction in power amplifiers, by Vanderkooy and Lipshitz. *Journal of the Audio Engineering Society*, January/February 1980.

www.americanradiohistory.com

(their 4c = 5a = 6a) are not easy to read, but offer 4mV pk-pk amplitude. The pulse appears to be rectangular, but to include as well perhaps a 60% overshoot on return. The overshoot then decays with time constant about 5μs. All this is encouraging, and can be made more so.

Taking median gain figures for the transistors in the driver, its input impedance would be 460kΩ, combining with C = 120pF to yield 55μs time constant. This is not likely to be the decay involved. But C_6 with R_{12} yields 3.3μs, or slightly more if the source driving V_{in} offers some impedance at r.f.

With the output described, crossover lasts 2.2μs, as seen in Fig. 11 from the effect on output of 1.4V transition at the driver output. Then initially C_6 offers a short circuit to ground for the rectangular pulse offered to it via Z_1 and Tr_2. But as the pulse developes it begins to compare with 3.3μs. Then C_6 has largely charged, and the pulse faces almost R_{12} instead of a short to ground. And when the pulse has finished C_6 has to discharge. It forces reverse current into Tr_2 and causes the overshoot noticed, which then decays as it should with time constant 4 to 5μs. The oscillogram provided is now well explained.

If the experiment were repeated with larger A, then crossover time would fall in proportion, and C_6 would not have time to develop significant charge. The circuit would tend to behave more as if R_{12} were shorted. Thus as A rises in this way the circuit moves from something like 10% unbalance in one direction, passing zero to arrive at 6% unbalance in the other.

These figures were justified earlier. Then as A rises in (13) the quantity e first falls towards zero and then rises on the other side. So initially not much increase in output distortion is expected, as these factors are behaving in opposition. But after a while distortion should rise rapidly, perhaps after the style of a square law, when both factors are pulling in the same direction. This is just what is reported: as A was increased up to 14V there was little increase in distortion, but as A climbed by a further factor of 2.5 distortion rose by a factor of five (observe approximate square law behaviour!)

Further progress would require more and clearer oscillograms.

Traditional amplifier

How does crossover distortion in the circuit of Fig. 11 compare with that present in an equivalent traditional amplifier? Some comparisons have been based on shorting Z_4 while leaving Z_2 in place but these need not detain us. It is clear that the capacitor Z_2 will then seriously inhibit the driver in its attempts to produce rapid transition of its output voltage during crossover. Hence no traditional amplifier would contain such a component.

A comparison was made above with a traditional amplifier, and it was found that there was no difference. But this supposed a dumping amplifier that had been perfectly balanced by (10). Now compare a dumping amplifier with unbalance leading to (13) with a traditional amplifier, and figures become essential.

The circuit of Fig. 11 may be converted into the equivalent traditional amplifier by shorting Z_4, and also removing Z_2. further, R_{12} should be shorted and C_6 removed: impedance cannot be tolerated in this area, and dv/dt limiting must be done earlier instead. Copy the circuit of Fig. 12 with these simplications.

Then D becomes equal to E, and if study is confined to the effects of V on E then C becomes just a multiple of E. As Tr_2 emitter input impedance is now low B can be taken as zero and all three unknown voltages that previously had to be eliminated have now vanished. The problem can be solved in two lines by applying the same current constraint as previously, and the contribution to E due to V becomes

$$E \approx -\frac{1}{gZ_{in}} \cdot \frac{Z_1}{Z_3} V.$$

As all components are resistive, E will just follow the waveform of V in this fashion. The worst figure of 50kΩ for Z_{in} produces 0.15mV pk-pk to complete Table 1.

Results

Current dumping has aroused much interest, and there have now been some 20 contributions to the discussion in this periodical alone. It has been suggested here that when the analysis takes account of the delivery of feedback to both ends of Tr_2 a new factor λ appears in the bridge balance (9). The new factor is due to the presence of R_{12} and may vary between 0.65 and 0.90 depending on the gain of Tr_2. Supposing that this gain has its median value it would appear that a 10% bridge unbalance is built into the design of the Quad 405. This result has been accurately verified by Vanderkooy and Lipshitz. Conclusion: R_{12} is causing unpredictable consequences and it must go. The bridge must be balanced.

But suppose this is accepted (or indeed rejected). Then the best attempt at bridge balance is to ensure that (10) holds. But this destroys the whole system, and an amplifier of traditional type and identical performance results if the dumping components Z_2 and Z_4 are removed, provided three other elements are adjusted.

Finally, tolerance errors prevent perfect balance of (10), and further distortion results, degrading the current dumping amplifier below its traditional equivalent. Final figures are in Table 1. It seems to be an improvement to use resistive rather than reactive dumping elements, and a further improvement to abandon them altogether.

The gain term in (9) is about 10^{-5} in the Quad 405, and it will almost certainly be small in any implementation of current dumping. Given the tolerances of the other terms it will scarcely be possible to take it into account. Then objections would apply unaltered to any alternative dumping circuit.

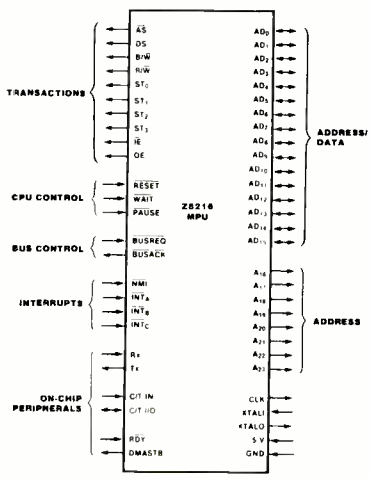
Part 1. On page 43 of the September article, the lower Z_4 in equation 5 should read Z_1.

The new Z80

Coinciding with the introduction of the 32-bit Z80000 mid next year Zilog plan to introduce the Z800 8/16-bit family of processors with Z80 software compatibility. With clock rates of up to 25MHz (preliminary information) and memory manipulation features, these devices will also make full use of current high-speed rams and, besides providing a stop-gap for the eight-to-sixteen bit transition, the family will act as input/output processors for the 16-bit Z8000. There are four devices: two with a 16-bit data bus, the Z8116 and 8216; and two with eight bits, the Z8108 and 8208. The 82 versions are physically larger than the other two i.cs and have four direct-memory access channels and built-in uart: all of the i.cs have four 16-bit counter timers.

The new processors have an integral memory-management unit that allows them to access either 512K-bytes or 16M-bytes, depending on the type, and they have 256 bytes of memory which, when configured as a 'cache', may be programmed to contain either instructions or data, or both. This speeds up program execution by reducing the number of external bus accesses. Operation and updating of the cache is automatic.

Although the instruction set will be expanded and augmented, all Z80 instructions are compatible with binary. Basic addressing modes of the Z80 will be augmented with the addition of a base-index mode and 16-bit displacements for indexed, program-counter-relative and stack-pointer-relative modes. These new addressing modes are incorporated into many of the old Z80 instructions. Additions to the instruction set include 8/16-bit signed and unsigned multiply and divide, 8/16-bit sign extension, and a test-and-set instruction for use in multi-processor applications. Sixteen-bit instructions include compare, memory increment/decrement, negate, add, and subtract.



Largest of the Z800 family, the 16-bit 8216, with Z80 instruction compatibility. Of the four devices, the two eigth-bit versions are compatible with the Z80 bus and the two 16-bit versions are designed for use with the 16-bit Z-Bus.

WW314 for further information

www.americanradiohistory.com

Rapid-update digital ratemeter

The normal method of digital frequency measurement is slow and inaccurate at very low frequencies, such as those encountered in medical research. This design enables pulse rate to be determined after only two heart beats.

by P. D. Coleridge Smith*
MA FRCS

It is often necessary to measure the heart rate of subjects undergoing intermittent exercise. When equipment for such application is to be used outdoors, it is essential that it should be robust, consume little power, be accurate to within 1% and indicate heart-beat between 40-240 beats per minute.

The need for robustness ruled out the use of a moving-coil meter: low power requirements and the need for legibility in daylight dictated the choice of a liquid-crystal display.

Rate conversion itself necessitated careful consideration. Rapid settling following switch-on and frequency change was required, since the subjects of the study were connected to the equipment immediately following exercise. An 'instant' indication of heart rate was essential and the meter had to be capable of closely following the change in rate.

A variety of analogue solutions were considered, from diode-pump ratemeters to analogue inverse-function generators. The simpler solutions would have taken too long to respond, the more complex suffered drift and difficult setting-up procedures. All, of course, would have required digital conversion before display.

These problems led to the final, all-digital design, in which a 10 bit binary counter measures the period between input pulses. An eprom uses the count as its address input, and contains a look-up table of rates at each of the 1024 points of the 10 bit counter, the data derived from the eprom being latched into display decoder/drivers: the circuit includes under- and overflow indication as well as leading-zero suppression. The instrument gives an accurate

*Academic Department of Surgery, Royal Free Hospital, London NW3.

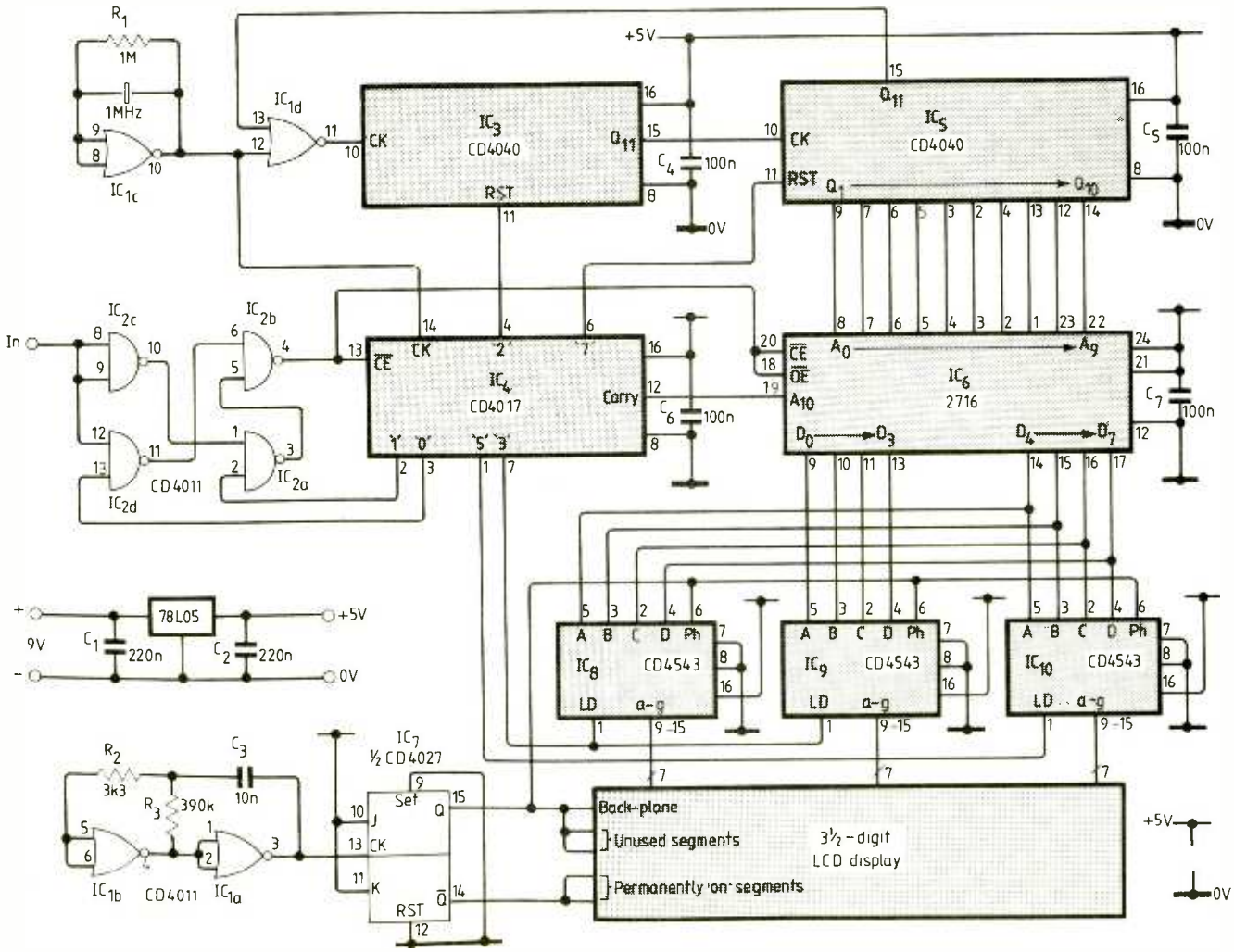


Fig. 1. Circuit diagram of complete ratemeter. Layout on stripboard is not critical.

www.americanradiohistory.com

Hexadecimal dump of eprom contents. This table also includes values for addresses where n<100, for development purposes. These may be altered as suggested in the text to indicate meter "overflow" if required.

000	0F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F
010	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	7F
020	6F	8F	2F	7F	4F	2F	1F	1F	2F	5F	8F	1F	6F	1F	7F
030	0F	8F	6F	4F	3F	3F	3F	3F	3F	4F	5F	7F	8F	0F	3F
040	6F	1F	4F	7F	1F	5F	9F	3F	7F	1F	6F	1F	5F	0F	6F
050	6F	2F	7F	3F	9F	5F	1F	7F	3F	9F	6F	2F	8F	5F	2F
060	5F	2F	9F	6F	3F	0F	7F	4F	2F	9F	6F	4F	1F	9F	6F
070	2F	9F	7F	5F	3F	0F	8F	6F	4F	2F	0F	8F	6F	4F	3F
080	9F	7F	5F	4F	2F	0F	9F	7F	5F	4F	2F	1F	9F	8F	6F
090	3F	2F	1F	9F	8F	7F	5F	4F	3F	1F	0F	9F	8F	7F	5F
0A0	3F	2F	1F	0F	9F	8F	6F	5F	4F	3F	2F	1F	0F	9F	8F
0B0	6F	6F	5F	4F	3F	2F	1F	0F	9F	8F	8F	7F	6F	5F	4F
0C0	3F	2F	1F	0F	9F	9F	8F	7F	6F	6F	5F	4F	4F	3F	2F
0D0	1F	0F	0F	9F	8F	8F	7F	6F	6F	5F	4F	4F	3F	3F	2F
0E0	1F	0F	0F	9F	8F	8F	7F	7F	6F	6F	5F	5F	4F	4F	3F
0F0	2F	2F	1F	1F	0F	0F	9F	9F	8F	8F	7F	7F	6F	6F	5F
100	4F	4F	4F	3F	3F	2F	2F	1F	1F	1F	0F	0F	9F	9F	9F
110	8F	7F	7F	7F	6F	6F	5F	5F	5F	4F	4F	4F	3F	3F	2F
120	2F	1F	1F	1F	0F	0F	0F	9F	9F	9F	8F	8F	8F	7F	7F
130	6F	6F	6F	5F	5F	5F	5F	4F	4F	4F	3F	3F	3F	2F	2F
140	2F	1F	1F	1F	0F	0F	0F	0F	9F	9F	9F	9F	8F	8F	8F
150	7F	7F	7F	6F	6F	6F	6F	5F	5F	5F	5F	4F	4F	4F	4F
160	3F	3F	3F	3F	2F	2F	2F	2F	1F	1F	1F	1F	0F	0F	0F
170	0F	9F	9F	9F	9F	9F	8F	8F	8F	8F	8F	7F	7F	7F	7F
180	6F	6F	6F	6F	6F	5F	5F	5F	5F	5F	4F	4F	4F	4F	4F
190	3F	3F	3F	3F	3F	2F	2F	2F	2F	2F	1F	1F	1F	1F	1F
1A0	0F	0F	0F	0F	0F	0F	9F	9F	9F	9F	9F	8F	8F	8F	8F
1B0	8F	8F	8F	7F	7F	7F	7F	7F	7F	6F	6F	6F	6F	6F	6F
1C0	5F	5F	5F	5F	5F	5F	5F	4F	4F	4F	4F	4F	4F	4F	3F
1D0	3F	3F	3F	3F	3F	2F	2F	2F	2F	2F	2F	2F	2F	1F	1F
1E0	1F	1F	1F	1F	1F	0F	0F	0F	0F	0F	0F	0F	0F	9F	9F
1F0	9F	9F	9F	9F	9F	8F	8F	8F	8F	8F	8F	8F	8F	7F	7F
200	7F	7F	7F	7F	7F	7F	7F	6F	6F	6F	6F	6F	6F	6F	6F
210	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	4F	4F	4F	4F	4F
220	4F	4F	4F	4F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	2F
230	2F	2F	2F	2F	2F	2F	2F	2F	2F	1F	1F	1F	1F	1F	1F
240	1F	1F	1F	1F	1F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F
250	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	8F	8F	8F
260	8F	8F	8F	8F	8F	8F	8F	8F	8F	7F	7F	7F	7F	7F	7F
270	7F	7F	7F	7F	7F	7F	7F	6F	6F	6F	6F	6F	6F	6F	6F
280	6F	6F	6F	6F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F
290	5F	5F	5F	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F
2A0	4F	4F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F
2B0	3F	3F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F
2C0	2F	2F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
2D0	1F	1F	1F	1F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F
2E0	0F	0F	0F	0F	0F	0F	9F	9F	9F	9F	9F	9F	9F	9F	9F
2F0	9F	9F	9F	9F	9F	9F	9F	9F	9F	8F	8F	8F	8F	8F	8F
300	8F	8F	8F	8F	8F	8F	8F	8F	8F	8F	8F	8F	8F	8F	7F
310	7F	7F	7F	7F	7F	7F	7F	7F	7F	7F	7F	7F	7F	7F	7F
320	7F	7F	7F	6F	6F	6F	6F	6F	6F	6F	6F	6F	6F	6F	6F
330	6F	6F	6F	6F	6F	6F	6F	6F	6F	5F	5F	5F	5F	5F	5F
340	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F	5F
350	5F	5F	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F
360	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F	4F	3F	3F	3F	3F
370	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F	3F
380	3F	3F	3F	3F	3F	3F	2F	2F	2F	2F	2F	2F	2F	2F	2F
390	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F	2F
3A0	2F	2F	2F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
3B0	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
3C0	1F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F
3D0	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F	0F
3E0	0F	0F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F
3F0	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F	9F

400	00	99	99	99	99	99	99	99	99	99	99	99	99	99	99
410	99	99	99	99	99	99	99	99	99	99	99	99	99	99	94
420	91	88	86	83	81	79	77	75	73	71	69	68	66	65	63
430	61	59	58	57	56	55	54	53	52	51	50	49	48	48	47
440	45	45	44	43	43	42	41	41	40	40	39	39	38	38	37
450	36	36	35	35	34	34	33	33	32	32	32	31	31	31	30
460	30	30	29	29	29	29	28	28	28	27	27	27	27	26	26
470	26	25	25	25	25	25	24	24	24	24	24	23	23	23	23
480	22	22	22	22	22	22	21	21	21	21	21	21	20	20	20
490	20	20	20	19	19	19	19	19	19	19	19	18	18	18	18
4A0	18	18	18	18	17	17	17	17	17	17	17	17	17	16	16
4B0	16	16	16	16	16	16	16	16	15	15	15	15	15	15	15
4C0	15	15	15	15	14	14	14	14	14	14	14	14	14	14	14
4D0	14	14	14	13	13	13	13	13	13	13	13	13	13	13	13
4E0	13	13	13	12	12	12	12	12	12	12	12	12	12	12	12
4F0	12	12	12	12	12	12	11	11	11	11	11	11	11	11	11
500	11	11	11	11	11	11	11	11	11	11	11	11	10	10	10
510	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
520	10	10	10	10	10	10	10	F9	F9	F9	F9	F9	F9	F9	F9
530	F9	F9	F9	F9	F9	F9	F9	F9	F9	F9	F9	F9	F9	F9	F9
540	F9	F9	F9	F9	F9	F9	F8	F8	F8	F8	F8	F8	F8	F8	F8
550	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8
560	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8	F8
570	F8	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7
580	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7
590	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7	F7
5A0	F7	F7	F7	F7	F7	F7	F6	F6	F6	F6	F6	F6	F6	F6	F6
5B0	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6
5C0	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6
5D0	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6
5E0	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F6	F5	F5
5F0	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5
600	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5
610	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5
620	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5
630	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5
640	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5	F5
650	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
660	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
670	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
680	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
690	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
6A0	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
6B0	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
6C0	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
6D0	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F4
6E0	F4	F4	F4	F4	F4	F4	F3	F3	F3	F3	F3	F3	F3	F3	F3
6F0	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
700	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
710	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
720	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
730	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
740	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
750	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
760	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
770	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
780	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
790	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
7A0	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
7B0	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
7C0	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
7D0	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3
7E0	F3	F3	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2
7F0	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2

indication of rate after the arrival of only two input pulses and correctly updates it after each subsequent pulse. It can be used in any application where the frequency of the input signal is 500Hz or less, and is well suited to use below 5Hz where other techniques involve excessive integration periods.

The low-level signal amplification and pulse extraction are achieved conventionally, using a high input-impedance differential amplifier to extract the subject's electrocardiogram voltages – of the order of 1-2mV peak – peak, which is subsequently converted to c.m.o.s. levels for connection to the ratemeter.

Circuit description

$IC_{1(c)}$ forms a 1MHz crystal oscillator, which is divided by 2048 in IC_3, resulting in an output of 488.28Hz to IC_5. These counters are controlled by IC_2 and IC_4, a decoded decade counter.

When the ratemeter input (pins 8, 9 and 12 of IC_2) is low, IC_4 counts up until the decoded '1' output goes high. $IC_{2(b)}$ then applies a high level to the clock-enable input of IC_4 and further counting ceases, whereupon a high level at the input again enables counting, with outputs 2 to 9 being taken high in sequence. The low level at IC_4 clock-enable also enables the 2716 eprom.

Output '2' from IC_4 resets IC_3, preventing any change in the count of IC_5 during the look-up procedure. This ripple counter, IC_5, provides the address for IC_6, which holds the rate data in a look-up table.

Output '3' latches the high-order data from IC_6 into display driver/latches $IC_{8,9}$. The carry output of IC_4 then goes low, selecting the lower half of the look-up table in IC_6, the data from which is latched by the '5' output into IC_{10}.

Output '7' then resets IC_5 ready for the next measurement cycle, the count output of IC_4 remaining at '0' until the input goes low again.

$IC_{1a,1b}$ and half of IC_7 provide a precise 1:1 duty cycle square-wave drive for the l.c.d. driver i.cs and display. A 3½ digit device has been used for convenience, with unused segments tied to the back-plane.

The entire look-up cycle takes place at a 1MHz clock rate, and is therefore complete in less than 9μs.

Should the interval between successive positive input transitions exceed that taken to count through the first ten stages of IC_5, output Q_{11} of IC_5 will go high. This inhibits further clock pulses to the counter chain via $IC_{1(d)}$ and stops the eprom address from IC_5 at zero. This location (0) in eprom contains a range underflow indi-

www.americanradiohistory.com

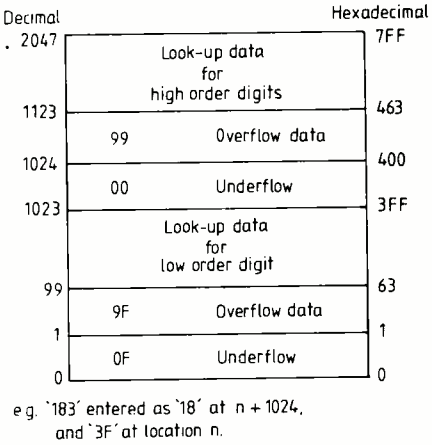


Fig. 2. Memory map of 2716 eprom.

cator – "000" in my original design.

The data in the eprom is derived from the simple formula:

$$\text{rate} = 60f_i/n \text{ (pulses per minute)}$$

where f_i is the input frequency to IC_5, 488.28 Hz in the diagram shown, and n is the eprom address in the range 0-1023. The rate for each of the memory locations was calculated and rounded to an integral number before being programmed using a microprocessor-based system. For locations with n<100, the entry was replaced with '999' to indicate meter overflow, since the accuracy in this address range does not fulfil design criteria.

The high-order digits are stored in the upper half of the eprom memory range in b.c.d. form, that is from 1024-2047 (decimal), while low-order digit data is located in the upper half of each byte from address 0-1023. The remaining half byte in each of these locations is not used in this application. Leading-zero blanking is accomplished by substituting a non-b.c.d. value (0-F hexadecimal) in place of the relevant zero. The CD 4543 responds to this code by blanking the digit concerned. Figure 2 is the complete memory map for the eprom.

Power is derived from a 9 volt battery via a 78L05 supply regulator to ensure that the rail requirements of the 2716 are not exceeded. The entire circuit consumes about 30mA, of which the eprom accounts for the greatest part.

Construction

The layout is non-critical and the prototype was constructed on Veroboard.

Setting-up is not required, since the clock runs within 0.1% of 1MHz without adjustment. The display oscillator should provide a final-drive frequency within the range 30-100Hz on pin 15 of IC_7 for optimum performance, and this again usually requires no adjustment.

Additional ranges

For an indication in Hertz, merely reprogram the eprom. Alternative frequency ranges can be accommodated by selecting the appropriate output from IC_3 to give a minimum of 100 counts in IC_5 at the high end of the frequency range (for 1% accuracy), bearing in mind that the meter will "underflow" after 1023 counts at IC_5. The required data for the eprom is easily calculated from the formula given above.

The remaining half of IC_7 can be used to divide the input signal by two, thus updating the display on alternate positive input transitions. The output from IC_3 must then be taken from Q_{12}, not Q_{11}, to ensure that the correct frequency is displayed. This is useful if the input frequency is slightly irregular and averaging over two consecutive periods is required.

BOOKS

Electronic Prototype Construction by Stephen D. Kasten, 398 pages. Prentice/Hall International, £15.25, soft covers. How to lay out and manufacture your own p.c.bs.

Mastering Electronics by John Watson, 382 pages. Macmillan, £10.00 hard cover. Electronics for the beginner – from basic physics to radio, tv and computing.

Learning Timex Sinclair Basic by David A. Lien, 331 pages. Compusoft Publishing, 535 Broadway, El Cajon, California 92021, USA, $14.95, soft cover. For ZX81 owners.

Learning IBM Basic by David A. Lien, 421 pages. Compusoft Publishing, $19.95, soft cover. For the IBM personal computer.

Science and Engineering Sourcebook by Cass Lewart, 96 pages. Prentice/Hall International, £8.45, paper cover. Scientific and engineering programs for the Sharp PC1211 and TRS-80 pocket computers.

Beginner's Guide to Computers by T. F. Fry, second edition. Newnes, 186 pages, £4.35, soft cover. Introduction to computers, both great and small, and their uses.

What do you do after you plug it in? by William Barden jr, 198 pages. Prentice/Hall International, £9.30, paperback. Chatty guide for newcomers to the microcomputer.

The World Connection by Timothy Orr Knight, 142 pages. Prentice/Hall International, £8.45, soft covers. The romance of the micro, by a 16-year-old enthusiast.

Using 6502 Assembly Language by Randy Hyde. Prentice/Hall International, £16.95, paper cover. Aimed mainly at Apple II users.

iAPX 88 Book by staff of the Intel Corporation, 80 pages. Prentice/Hall International, £11.00, paper cover. All about the Intel 8088 8-bit microprocessor.

Microprocessors and Digital Systems by Douglas V. Hall, second edition, 464 pages. McGraw-Hill, £19.00, hard cover. Comprehensive guide for the technician.

Security Electroncis by John E. Cunningham, third edition, 255 pages. Prentice/Hall International, £11.85, paper cover. Techniques for keeping intruders out of cars, property and computers.

Basic Electrical Installations by Michael Neidle, third edition, 79 pages. Macmillan, £3.95, soft cover.

Electrical Installations and Regulations by Michael Neidle, third edition, 99 pages, Macmillan, £4.95, soft cover.

Electrical Installation by A. O. Akintante and J. M. Hyde, 146 pages. Macmillan Introduction to Technology Series, Macmillan, £3.25, soft cover.

IC Timer Cookbook by Walter G. Jung, second edition, 384 pages. Prentice/Hall International, £15.25, soft cover. Everything there is to know about the 555 and its cousins.

A Z80 Workshop Manual by E. A. Parr, 184 pages. Bernard Babani, £2.75, soft cover. Assembly language and machine code for the ZX81, Spectrum, Nascom, TRS80 etc.

Easy Add-on Projects for Spectrum, ZX81 & Ace by Owen Bishop, 182 pages. Babani, £2.75, soft cover. 17 projects including a light-pen, a model railway controller and an anemometer, with software suggestions in Basic and Forth.

Video User's Handbook by Peter Utz, second edition, 500 pages. Prentice/Hall International, £11.95, soft cover. Production methods and tv techricalities for community tv people.

Computer Communication Techniques by E. G. Brooner and Phil Wells, 142 pages. Prentice/Hall International, £13.55, soft cover. Details of the various interface standards and protocols, plus an outline of public data systems, computer networks and packet radio.

Radio and Television Servicing, 1982-83 models edited by R. N. Wainwright, 767 pages. Macdonald, £22.50, hard cover. Circuit diagrams and servicing hints for a wide range of British and foreign sets.

SPSSX User.s Guide (SPSS inc.), 806 pages. McGraw-Hill, £24.25, soft covers. Mammoth guide to the SPSSX computer language and its uses.

Microelectronics: practical approaches for schools & colleges edited by Graham Bevis and Mike Trotter, 94 A4-size pages plus two small wall-charts doubling as overhead projection transparencies. BP Educational Service, with the Microelectronics Education Programme and BBC Schools Radio, £2.75, soft cover. Lots of things to do, andhow to do them; great fun for beginners young or old.

Microcomputer companiesin the UK (eurolec 58) edited by John Beaven, 370 pages, soft cover. £32 plus £2 post and ,acking from Eurolec, 6 Woodbury Lane, Clifton, Bristol BS8 2SD. Guide to more than 1700 micro hardware and software suppliers.

A user guide to the UNIX system by Rebecca Thomas and Jean Yates, 510 pages. McGraw-Hill, £12.95, soft cover. At-the-keyboard tutorial course for users of this computer operating system, widely used on machines from mainframes to micros.

IBM Personal Computer Technical Reference Manual. International Business Machines, £31, loose-leaf with ring-binder. How the hardware works, for engineers and programmers. Includes circuit diagrams and operating system rom losting.

www.americanradiohistory.com

Microcomputer analysis of a ladder network

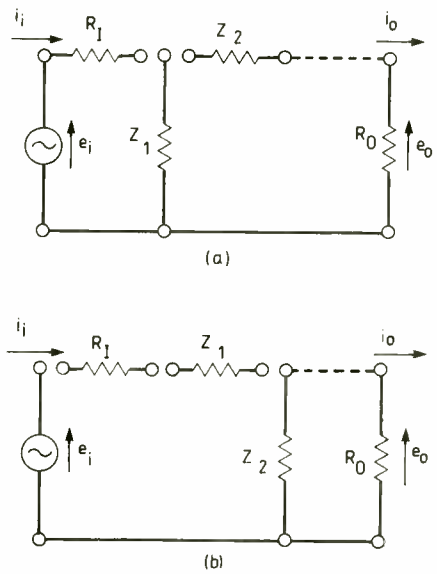
Flow diagrams enable a program for ladder network insertion loss and its delay equalization written for a ZX81 to be modified for other computers

by L. E. Weaver

Since the publication of my article "Network analysis with a ZX81" in Wireless World (August and September 1982 issues) I have received appeals for help in adapting the program for micros other than the ZX81. Such a procedure is always full of well-concealed traps even when the dialect of Basic is nominally the same, and after many tedious hours at the v.d.u. I am convinced that in nearly every instance it pays handsomely to start by understanding how the program work, and then to rewrite it for one's own machine and in one's own way. This is all the more valid when the program was originally written for the ZX81, which has certain idiosyncracies.

What I have done, therefore, is to rewrite the program slightly in a form which is likely to be more generally acceptable to other micro-computers, while keeping the overall format the same to facilitate cross-referencing. The result is given in the form of a series of flow diagrams which point to the relevant lines in the original. As a further aid, these lines or sequences of lines are reproduced in an appendix.

First, a brief review of the method of analysis of the network and the development of the fundamental algorithm. Figs 1(a) and 1(b) show the two possible configurations, the first with shunt input and the last with series. We need to determine the ratio of the voltage across the output termination RI to that of the generator feeding the output termination RO, that is e_0/e_i, complex quantity, say a+jb. Then the insertion loss is $10\log_{10}(a^2+b^2)/4$, and the insertion phase shift



$\beta = \arctan(b/a)$.

The starting point is the A-matrix for the input termination which, as it must always be considered to be in series, is

$$\begin{matrix} 1 & RI \\ 0 & 1 \end{matrix}$$

The A-matrix of the first reactance arm is then added by matrix multiplication, followed by all of the other arms in sequence. Finally, the output termination is added in shunt. The process can be generalized as follows.

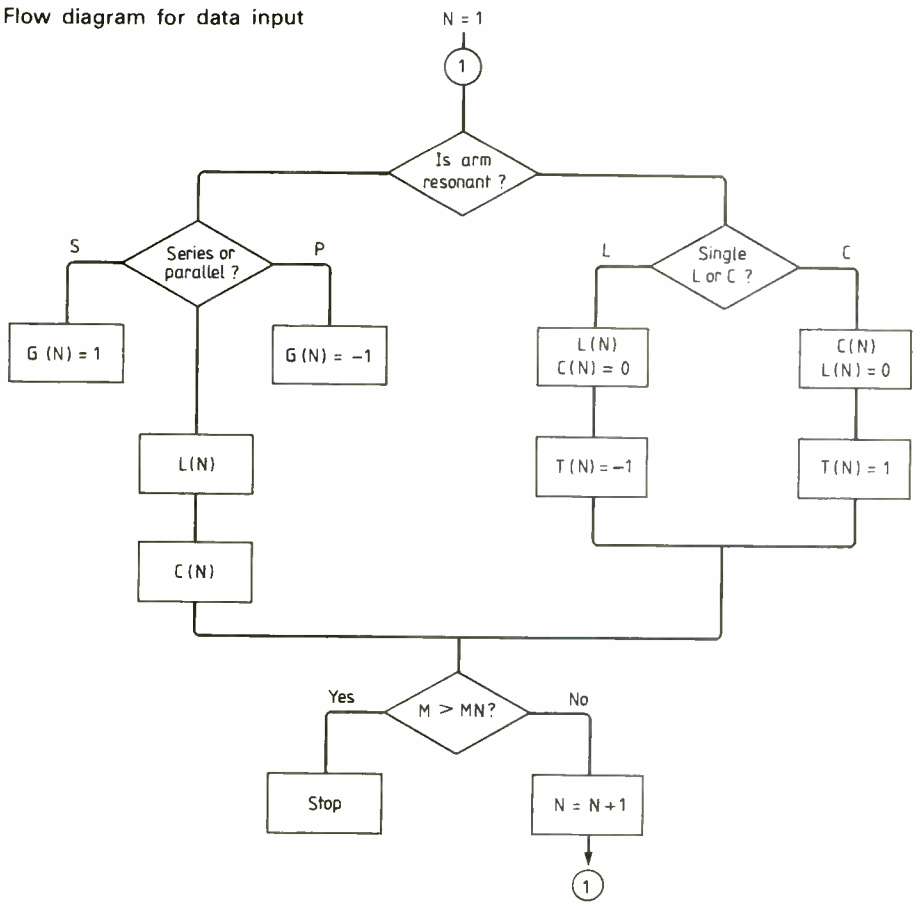
Stage 1: data input

The program can be conveniently divided into distinct stages, each with its own flow diagram. The first step is the input of the basic data, i.e.

- FO is starting frequency for the computation (MHz)
- FM is finishing frequency (MHz)
- DF is frequency step (MHz)
- D is dissipation constant
- FD is the frequency associated with D. Remember that D is a function both of the resistive component of a reactor and its reactance. Usually, FD is made the frequency of maximum D over the range of interest, also in MHz.
- RI is the value of the input termination (ohms)
- RO is the value of the output termination (ohms)
- the number of branches NM. These must be alternately series and shunt, or vice versa.

The next step is to input the reactance values into the arrays L(N) and C(N), where N is the number of the branch starting from the input. Each reactance arm is allowed one inductor and one capacitor, where either may be allocated the value zero. This is not a restriction on the applicability of the program. It was demonstrated back in the original article

Flow diagram for data input



www.americanradiohistory.com

(August 1982) that arms with three or more components can be dealt with by means of a simple device.

The method used should be clear from the flow diagram of Fig. 2. Each arm in succession is flagged by means of the arrays T(N) and G(N) to indicate unambiguously whether it contains a series resonant circuit, a parallel resonant circuit, an inductor only, or a capacitor only. Although it is not shown in Fig. 2, it is very disirable to STOP the program when all entries have been made, and GOTO a subroutine listing all inputs with the corresponding branch numbers. Without a check of this kind, errors are all too likely. If at some point in this process the matrix has become

$$\begin{matrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{matrix},$$

then after the addition of a series arm Z_s, this becomes

$$\begin{matrix} Z_{11} & Z_{12}+Z_s \cdot Z_{11} \\ Z_{21} & Z_{22}+Z_s \cdot Z_{21} \end{matrix},$$

and after the addition of a shunt arm Z_p

$$\begin{matrix} Z_{11}+Z_{12}/Z_p & Z_{12} \\ Z_{21}+Z_{22}/Z_p & Z_{22} \end{matrix}.$$

At the end, after the addition of the output termination, the matrix element $Z_{11}=e_0/e_i$ gives the insertion loss and phase. The element Z_{21} is not unimportant as it is the input impedance of the network as seen through the input termination RI. However, in the original program this was not required, so that the second row of the matrix does not enter into the computation and may therefore be ignored.

The final result is a pair of what must more correctly be called algorithms, although for the sake of convenience they will still be referred to as matrices:

$Z_{11}Z_{12} \rightarrow Z_{12}+Z_s \cdot Z_{11}$
addition of series arm Z_s

$Z_{11}Z_{12} \rightarrow Z_{11}+Z_{12}/Z_pZ_{12}$
addition of shunt arm Z_p

Each term can be a complex number so that an array of the form A(1,4) is required for the representation of the working matrix, where A(1,1)+jA(1,2) is used for Z_{11}, and A(1,3)+jA(1,4) for Z_{12}.

Stage 2: computation of loss and delay

This part of the program has been modified slightly from the original to make it more transportable, although the general format and the line numbering have been left unchanged to facilitate cross-referencing. The flow diagram is given in Fig. 3; bracketed numbers against the boxes are the relevant line numbers. For the sake of those without access to the September 1982 issue these program segments are provided in the Appendix, again with minimum changes. Any changes needed for a particular machine or dialect of Basic should be fairly evident.

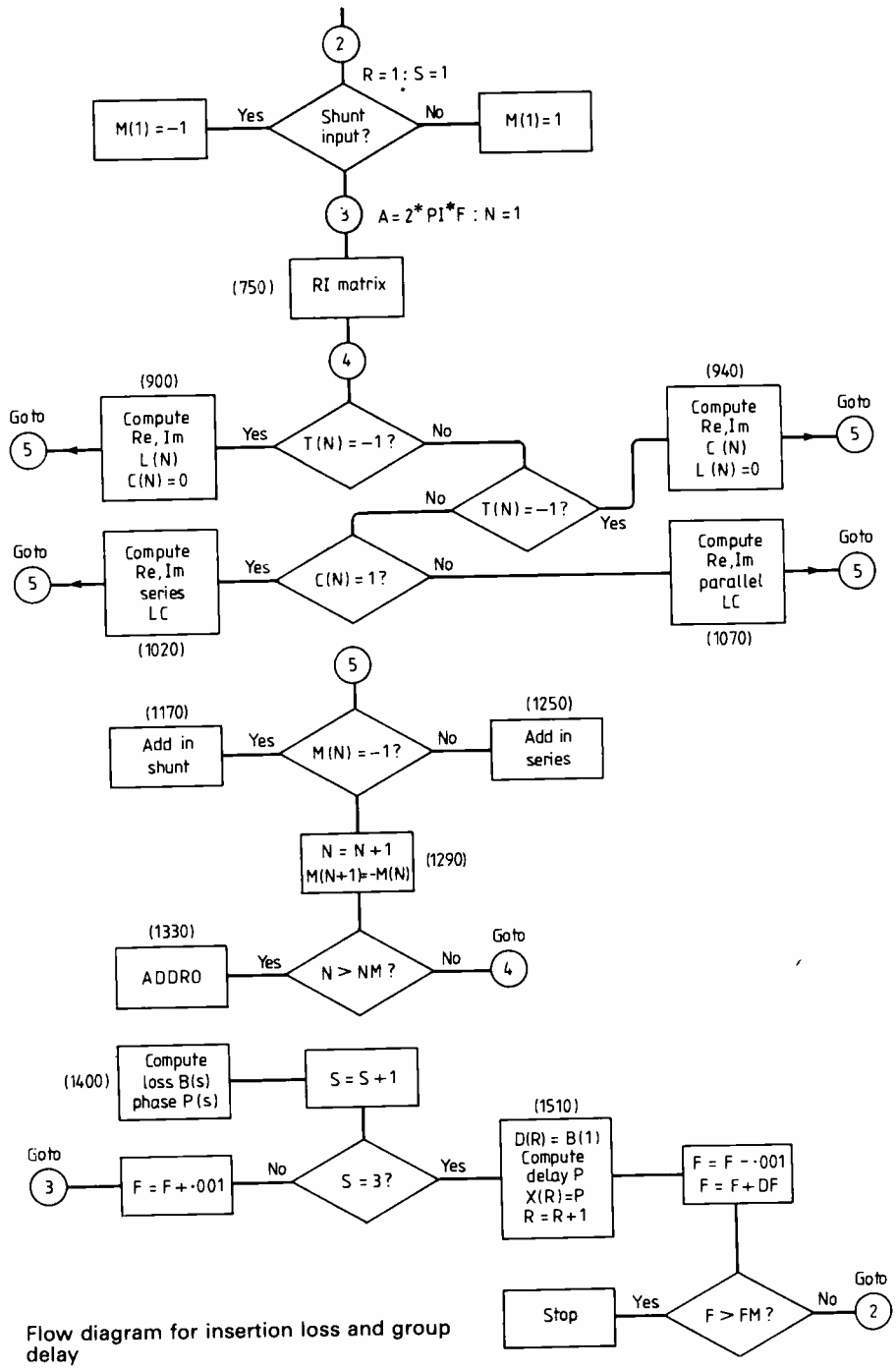
One vital piece of information is required before computation can start, that is whether the first arm of the ladder is in series or shunt. This input sets the first element of the M(N) array to −1 or +1 respectively. Execution can then proceed to the setting up of the initial matrix, that corresponding to the input termination RI. Because the 'matrix' is now only a single row, array A(1,4) suffices. At the same time, the arm number N is set to 1.

The arrays of flags T(N) and G(N) are then interrogated to determine the type of reactance arm, the real part Re and the imaginary part Im of which are then determined by the appropriate program segment. These are next combined with the matrix A(1,4) either as series or shunt impedances as directed by the array M(N). At the end of each pass N is incremented by 1 and the sign of M(N+1) is inverted compared with M(N), thus maintaining the alternating sequence of series and

Passive networks are alive and well . . .

In spite of some predictions, passive networks are still in wide-spread use, especially in the form of video low-pass filters. Their performance is defined in terms of the change in the transmission of a circuit having a definable impedance when opened and the filter inserted; the relevant parameters are insertion loss and group delay. To improve the transient response it is usually necessary to add constant-resistance delay correction sections which ideally improve the group delay characteristic without modifying the loss.

In the August and September issues, a program showed how to compute all of this on a simple domestic microcomputer. The basis was a matrix addition of the successive ladder impedances, which reduced to a simple algorithm. Dissipation could easily be taken into account. This program has been slightly modified and presented again in a more generalized form to enable readers to adapt it to individual needs.



Flow diagram for insertion loss and group delay

www.americanradiohistory.com

shunt arms. This is an in-place calculation, so that as soon as N=N+1, the loss and tanβ may be computed from A(1,1) and A(1,2). However, the last-mentioned does not provide the group delay, which is defined as dβ/dω, where the d's represent infinitesimally small increments in β and ω=2πF. Although there are a few networks whose group delay can be calculated directly, the best one can do in the general case is to add a small increment to F and recalculate β. In the present instance this was chosen to be 0.001, although even smaller values are possible depending upon the quality of the arithmetic of the micro.

The two values for tanβ are held in the arrays P(1) and ((2), hence tan Δβ can be computed from the familiar trigonometrical relation tan Δβ=(P(2) − P(1))/(1+P(1).P(2). In fact, there is no need to take the arctan of this expression to obtain Δβ: with video filters the incremental angle in radians is so small as to be equal to its tangent to a high degree of accuracy. For example, suppose the group delay is 1μs, a likely value for a video filter. Then one can see by inspection that the angle will be about 0.006rad. The second term in the expansion of tanΔβ is $(0.006)^3/3$, the first being Δβ, so the error is evidently completely negible. The group delay in μs is then Δβ/(.002I). These computed values are stored in the array X(R) for use in Stage 3 of the program.

As the variable S is incremented by 1 with each pass, S=3 indicates that the computation of the group delay has been terminated. At this point, 0.001 is subtracted from F and DF added to it, and the whole process is repeated for the new frequency unless F is found to be greater than FM, when the program is stopped. This allows the computed values to be listed, printed, or displayed as required.

One special point – the imaginary part of a capacitative impedance contains F in the denominator, so an error will be shown unless measures are taken. The simplest precaution is to replace F=0 by some very small quantity initially, and then to restore F=0 at the end of the relevant computation. This may be 1E−6, or even less depending upon the micro, so no practical error is involved. The published program used a more complex method where division by zero is avoided at each step where it could occur, but the suggested alternative is just as effective. It is not shown in the flow diagram of Fig. 3 for the sake of clarity.

Stage 3: group delay equalization

Group delay equalization is carried out by means of constant-resistance equalisers, used as a combination of first and second-order sections. Although higher orders exist, they are rarely used because of their complexity and difficulty of adjustment. In any case, all possible characteristics are feasible with only first and second orders.

First-order sections are defined by a single resonant frequency only, whereas second-order types require a shape factor K in addition to the resonant frequency FR. During the initial data entry it is convenient to make K=0 for a first-order section, providing an automatic indicator of the type of section. The only other input needed is the total number of sections V. Because of alignment problems, it is advisable to use not more than four unless unavoidable.

In the flow diagram in Fig. 4 the variable M is used as a counter, and as FR and K are entered they are stored in the arrays F(M) and K(M) respectively. Then the already-computed group delay values for the filter in Z(R) are copied into the array Z(R). The reason for this becomes evident later. A maximum of 15 frequencies is assumed, but this number is convenient rather than significant, and can readily be changed.

The next step is to calculate the group delay of each section in turn for the frequency F and to add it to the value held in Z(R). This is repeated for all frequencies up to the limit chosen of FM. But for equalization the deviations from flatness are easier to deal with if the output has the form of the equalized delay with the zero-frequency value subtracted, that is Z(R)−Z(1). This last quantity is also important and should be made available.

The program is stopped at this point for inspection of the results. Revised figures for K(M) and F(M) can then be entered, and as the original filter delay is still held intact in array Z(R), the process can quickly be repeated.

The question then remains of the dissipation of the delay equalizer, often far from negligible, and gives rise to undesirable undulations in the pass band loss characteristic of the filter. Provided D is not too large, say not greater than 0.02, Mayer's theorem is capable of furnishing a very good approximation to the variations due to the equaliser dissipation, and leads

Appendix: Essential Program Segments

```
750   LET A(1,3) = RI                          (initial matrix)
760   LET A(1,1) = 1
770   LET A(1,2) = 0
780   LET A(1,4) = 0

900   REM L ONLY
910   LET RE = FD*L(N)*D/2
920   LET IM = L(N)*A

940   REM C ONLY
960   LET RE = D/(2*FD*C(N))
970   LET IM = -1/(A*C(N))

1020  REM SERIES LC
1030  LET H = SQR(1/(L(N)*C(N))
1040  LET X = A/H
1055  LET RE = H*D*L(N)
1060  LET IM = H*L(N)*(X-1/X)

1070  REM PARALLEL LC
1080  LET H = SQR(1/(L(N)*C(N))
1090  LET X = A/H
1110  LET J = (X-1/X)*(X-1/X) +D*D
1120  LET L1 = H*L(N)
1130  LET RE = L1*D/J
1140  LET IM = -L1*(X-1/X)/J

1170  LET DE = RE*RE + IM*IM                   (addition of shunt arm)
1180  LET A(1,1) = A(1,1) + (A(1,3)*RE + A(1,4)*IM)/DE
1190  LET A(1,2) = A(1,2) +(A(1,4)*RE - A(1,3)*IM)/DE

1250  LET A(1,3) = A(1,3) + A(1,1)*RE - A(1,2)*IM   (add series arm)
1260  LET A(1,4) = A(1,4) + A(1,1)*IM + A(1,2)*RE

1330  LET A(1,1) = A(1,1) + A(1,3)/RO          (addition of RO)
1340  LET A(1,4) = A(1,2) + A(1,4)/RO

1400  LET LO = A(1,1)*A(1,1) + A(1,2)*A(1,2)   (insertion loss
1410  LET B(S) = 10*LOG(LO/4)/LOG(10)                computation)
1420  LET P(S) = A(1,2)/A(1,1)                 ( tan β )

1510  LET X(R) = ((P(2)-S(1))/(1+P(1).P(2))/(.002*PI)    ( d β/dω )
1840  LET T = F/F(M)                   (1st order equaliser sections)
1850  LET S = PI*F(M)*(1+T*T)
1860  LET Z(R) = Z(R) + 1/S

1880  LET T = F/F(M)
1890  LET U = (1-T*T)*(1-T*T)
1900  LET S : (1+T*T)*K(M)/(U+K(M)*K(M)*T*T)
1910  LET Z(R) = Z(R) + S/(PI*F(M))
1920  LET M = M +1

2100  FOR R = 1 TO 15                   (add loss from dissipation in
2110  LET L = 17.37*PI*F*(Z(R)-X(R))*D              delay equaliser)
2120  LET D(R) = D(R) + L
2130  (output D(R) as required)
2140  NEXT R
```


www.americanradiohistory.com

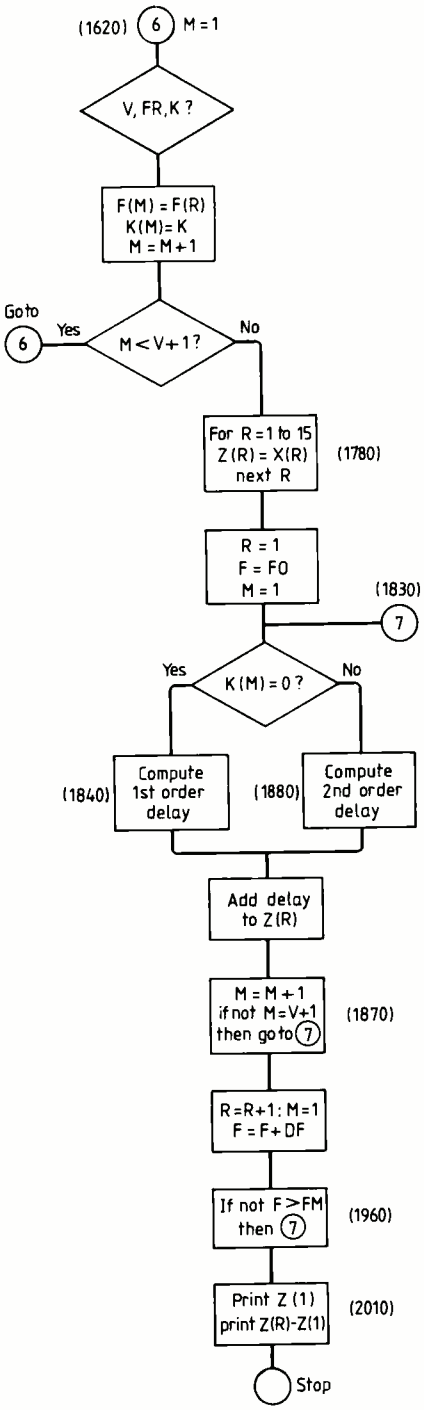
to a very simple subroutine (line 2100). The published program gives the actual variations, but by adding another line just after line 1410 to hold the insertion loss figures B(1) in a new array D(R), it is simple to provide the sum of the two, that is the filter loss plus the delay equalizer dissipation loss.

NewBrain modification

To provide some check on the portability of the program, it was typed into a NewBrain AD with only minor modifications, such as the omission of all LET commands and GOTO's in conditional statements. The general format, and the line numbering were deliberately left intact. A useful feature of this micro is the ability to choose the dimension base of arrays to be unity, as in the ZX81, or zero as in many other machines, so there was no need to change any array dimensions as the program was entered.

The results were very satisfactory. The speed of the program was very noticeably increased, and the accuracy was estimated to be at least an order of magnitude better. In addition, the high-resolution graphics were a valuable aid. The program could obviously be improved still further by rewriting it specifically for this particular computer. In general, this is the approach recommended to anyone wishing to use this method of network analysis. Even the flow diagram is not sacrosanct, and once the general principles have been grasped it may prove advantageous to modify it to suit one's own circumstances. WW

Flow diagram for delay equalization



LITERATURE RECEIVED

Flat cables and i.d.c. connectors along with suitable accessories and tools all constitute part of the Scotchflex system described in a 32-page brochure which also gives details of a breadboarding system for the rapid production of prototyping cricuits. Copies are available from Carolyn Morris, Electronics Products Group, 3M United Kingdom Plc, PO Box 1, Bracknell, Berks RG12 1JU.
WW 401

Cable identification products, including cable sleeves and markers, tools to fit them, cable ties and heat-shrink tools are all described in a catalogue from Siegrist-Orel Ltd, Hornet Close, Pysons Road Industrial Estate, Broadstairs, Kent CT10 2LQ.
WW 402

A six-page fold-out brochure gives full technical information on an 'advanced' carrier frequency instrumentation amplifier which may be used with a variety of bridge transducers. It features an automatic system to balance the bridge in amplitude and phase. Once balanced, the amplifier may be locked by touching a switch. The balance values are automatically stored. The 5kHz carrier frequency allows measurements up to 2000Hz. The KWS 83 brochure is available from Hottinger Baldwin Messtechnik, Howard House, The Runway, Ruislip, Middlesex HA4 6TH.
WW 403

Advance product information has been received on the Ferranti ZN440/ZN441 video a-to-d converters. ZN440 has a 16MHz sample rate and the converters may be stacked so that the initial 6-bit resolution may be expanded to 7 or 8 bits. The ZN441 has a 10MHz sample rate. Applications include high-speed data acquisition, video and radar data conversion, digital signal storage and image processing. Ferranti Electronics Ltd, Fields New Road, Chadderton, Oldham OL9 8NP.
WW 404

A wide range of DIN two-piece p.c.b. connectors are detailed in a 26-page catalogue of the 100/101 range from Panduit Ltd, Lordswood Industrial Estate, 61-65 Revenge Road, Chatham, Kent ME5 8YT.
WW 405

British Standard 4727 is, or will be when it's complete, a glossary of electrotechnical, power telecommunications and electronics, lighting and colour terms. Group 01 of Part 1 gives the fundamental terminology of those terms common to power, telecommunications and electronics. In effect it is a useful dictionary of units, effects and functions. BSI, 2 Park Street, London W1A BS.

The components catalogue of Ambit International seems to grow bigger each time it is issued. The latest version is in two forms: an industrial version available free to bona fide professional customers, and the consumer/enthusiasts edition available through newsagents at 80p. All items are described and priced and there is the Rewtel system for ordering goods via a computer link-up. Ambit International, 200 North Service Road, Brentwood, Essex CM14 4SG.
WW 407

The services of C & S Antennas, who design and make broadcasting and specialised antennae, are described in a glossy brochure. Their extensive R & D facilities enable them to offer aerials for almost any application. C & S Antennas Ltd, Knight Road, Strood, Rochester, Kent ME2 2AX.
WW 408

Computer peripheral equipment, including cartridge tape drives and storage systems, tape communications terminals and printers is described in the catalogue of Quantex equipment. Details are also given of the Diabolo-compatible user-programmable impact printer, Model 7040; and a Model 410 high-density cartridge tape streamer and Winchester back-up system. The catalogue comes from Euro Electronics Ltd, Twyman House, 31 Camden Road, London NW1 1YE.
WW 409

A colourful wallchart provides full technical specification of the Sharp range of l.e.d s and l.c.d. devices. Some 42 types are described with type number, colour, lens (shape and type), luminous intensity, viewing angle, current requirement and package outline. The chart is available from Impectron Ltd, Foundry Lane, Horsham, W. Sussex RH13 5PX.
WW 410

Until recently the design of l.s.i. circuits has been the exclusive province of the large semiconductor manufacturers. Now i.cs can be designed by equipment engineers and to help this happen MEDL has produced a design guide, *Designing on Silicon with MEDL*. This 58-page publication introduces the subject, guides an engineer through the various stages and lists the library of gate array cells and other building blocks available. Marconi Electronic Devices Ltd, Doddington Road, Lincoln LN6 0LF.
WW 411

More on p.56

www.americanradiohistory.com

No Contest!

The SC61 waveform analyser from Sencore stands head and shoulders above any other oscilloscopes for speed, accuracy and versatility even from semi-skilled operators — **and we're prepared to come round and prove it.**

For an on-site test and more information:
Mike Dawson 01-897 6446.

Hunting

Fieldtech Heathrow

Fieldtech Heathrow Limited
Huntavia House 420 Bath Road
Longford Middlesex UB7 0LL
Telex: 23734 FLDTEC G

WW – 031 FOR FURTHER DETAILS

ELECTRONIC COMPONENTS

★ **ELECTRONICS** ★ **COMMUNICATIONS** ★ **COMPUTING** ★ **VIDEO** ★ **AUDIO**

★ **3 x £1 DISCOUNT Vouchers as usual**

★ **PRICE-ON-THE PAGE**

Adaptors
Aerosols
Ammeters
Amplifiers
Audio Leads
Auto Modulation Meter
Batteries
Beads — Ferrite
Books — Technical
Bridge — Rectifiers
Bulbs
Cable
Cable Accessories
Cabinet Feet
Cage Jacks
Capacitors
Cases
Cassette Mechanisms
Caps — Keytops
Ceramic
Cermet Preset
Chassis Punches
Chargers — Battery
Chokes — Min Fixed
Cleaning Blocks
Clocks — LCD
CMOS ICs
Computer Leads
Connectors
Co-ax Relay
Contact Cleaner Aerosol
Copper Clad PCB
Cores
Coils
Converters
Crystals
Data Books
Die Cast Boxes
Displays
Diodes
Dot Matrix LCD Module
Double Balanced Mixer
Drafting Aids
Drawing Pen
Drills
Drive Cord
Earpieces
Enamelled Copper Wire
Encoder Rotary
EPROM Eraser
Equipment Cases
Etching Kit
Etch Resist Pen
Ferric Chloride
Ferrite
FET Dip Oscillator
File Set
Filters
Fixed Inductors
Fluorescent Displays
Frequency Counter
Function Generators
Generators
Helical Filter
High Pass Filter
ICs
IF Transformers
Keyboard Switches
Keypad
Keyswitch Caps
LCD Displays
LCD Modules
Lever Switches
Linear ICs
Linear Phase Filters
Low Pass Filters
Mechanical Filters
Meters
Miniature Loudspeakers
Miniature Relays
Mixer Diodes
Ni-Cad Batteries
Noise Measuring Equipment
Oscilloscopes
Oscilloscope Probes
PCB Aids
PCB
Potentiometers
Presets
Quartz Crystals
Resistors
Resonators
Rotary Switches
Screwdrivers
SCRs
Semiconductors
Silicon Compound
Silicon Diodes
Silver Plated Wire
Sleeving
Stereo Decoders
Switches
Tape Mechanism
Terminal Blocks
Thermometer
Transformers
Transformers Mains
Trim Tools
Trimmers
TVI Filters
TV Modulators
Variable Inductors
Varicap Diodes
Video Adaptors
Video Leads
Voltmeters
Voltage Regulators
VU Meters
Zener Diodes
Zero Insert Force Socket
Z-8 Development Systems

ambit INTERNATIONAL

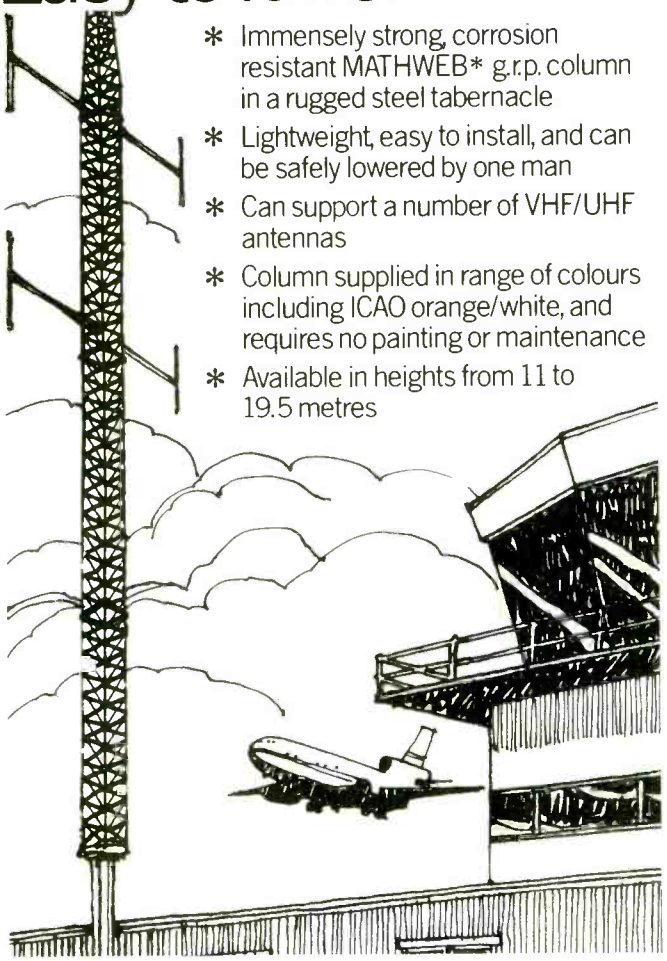
200 North Service Road, Brentwood, Essex CM14 4SG
Telephone (Consumer Sales/Enquiries) 0277-230909 — Telephone (Industrial Sales/Enquiries) 0277-231616 — Telex 995194 AMBIT G — Data 24 hrs (RS232/300 baud) 0277-232628; REWTEL

WW – 045 FOR FURTHER DETAILS

www.americanradiohistory.com

Marconi Type R1020 Hinged Antenna Column.

Easy to raise Easy to lower



* Immensely strong, corrosion resistant MATHWEB* g.r.p. column in a rugged steel tabernacle
* Lightweight, easy to install, and can be safely lowered by one man
* Can support a number of VHF/UHF antennas
* Column supplied in range of colours including ICAO orange/white, and requires no painting or maintenance
* Available in heights from 11 to 19.5 metres

OTHER MARCONI SUPPORT STRUCTURES
Include the MATHWEB* Lattice Antenna Mast Type R1010, and the Triangular Section Tubular Steel Self Supporting Tower Type R1060.

For more information talk to Chris Pettitt, Marketing Manager, Antenna Systems Division.

* MATHWEB is a registered trademark of the BP Group

Marconi
Communication Systems

Antenna Systems Division
Marconi Communication Systems Limited,
Lane Works, Waterhouse Lane, Chelmsford CM1 2QX, England
Tel: 0245 67111 Telex: 99201

A GEC-Marconi Electronics Company

WW – 009 FOR FURTHER DETAILS

Sowter Transformers

With 40 years' experience in the design and manufacture of several hundred thousand transformers we can supply:

AUDIO FREQUENCY TRANSFORMERS OF EVERY TYPE
YOU NAME IT! WE MAKE IT!
OUR RANGE INCLUDES

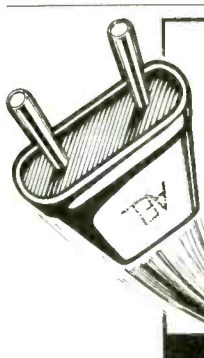
Microphone transformers (all types), Microphone Splitter/Combiner transformers. Input and Output transformers, Direct Injection transformers for Guitars, Multi-Secondary output transformers, Bridging transformers, Line transformers, Line transformers to G.P.O. Isolating Test Specification, Tapped impedance matching transformers, Gramophone Pickup transformers, Audio Mixing Desk transformers (all types), Miniature transformers, Microminiature transformers for PCB mounting, Experimental transformers, Ultra low frequency transformers, Ultra linear and other transformers for Transistor and Valve Amplifiers up to 500 watts, Inductive Loop Transformers, Smoothing Chokes, Filter, Inductors, Amplifier to 100 volt line transformers (from a few watts up to 1,000 watts), 100 volt line transformers to speakers, Speaker matching transformers (all powers), Column Loudspeaker transformers up to 300 watts or more.

We can design for RECORDING QUALITY, STUDIO QUALITY, HI-FI QUALITY OR P.A. QUALITY. OUR PRICES ARE HIGHLY COMPETITIVE AND WE SUPPLY LARGE OR SMALL QUANTITIES AND EVEN SINGLE TRANSFORMERS. Many standard types are in stock and normal dispatch times are short and sensible.
OUR CLIENTS COVER A LARGE NUMBER OF BROADCASTING AUTHORITIES, MIXING DESK MANUFACTURERS, RECORDING STUDIOS, HI-FI ENTHUSIASTS, BAND GROUPS, AND PUBLIC ADDRESS FIRMS. Export is a speciality and we have overseas clients in the COMMONWEALTH, E.E.C., USA, MIDDLE EAST, etc.
Send for our questionnaire which, when completed, enables us to post quotations by return.

E. A. Sowter Ltd.

Manufacturers and Designers
E. A. SOWTER LTD. (Established 1941) : Reg. No. England 303990
The Boat Yard, Cullingham Road, Ipswich IP1 2EG, Suffolk
P.O. Box 36, Ipswich, IP1 2EL, England
Phone: 0473 52794 and 0473 219390
Telex 987703G Sowter

WW – 016 FOR FURTHER DETAILS



AEL AT SPEED

TO BE CRYSTAL CLEAR
Tel. 029-34-5353 Telex 87116 Aero G
MOD approved CAA approved

WW – 028 FOR FURTHER DETAILS

IN VIEW OF THE EXTREMELY RAPID CHANGE TAKING PLACE IN THE ELECTRONICS INDUSTRY, LARGE QUANTITIES OF COMPONENTS BECOME REDUNDANT. WE ARE CASH PURCHASERS OF SUCH MATERIALS AND WOULD APPRECIATE A TELEPHONE CALL OR A LIST IF AVAILABLE. WE PAY TOP PRICES AND COLLECT.

BROADFIELDS & MAYCO DISPOSALS
21 Lodge Lane, N. Finchley, London, N.12. 5 mins. from Tally Ho corner
Telephone 445 2713/0749

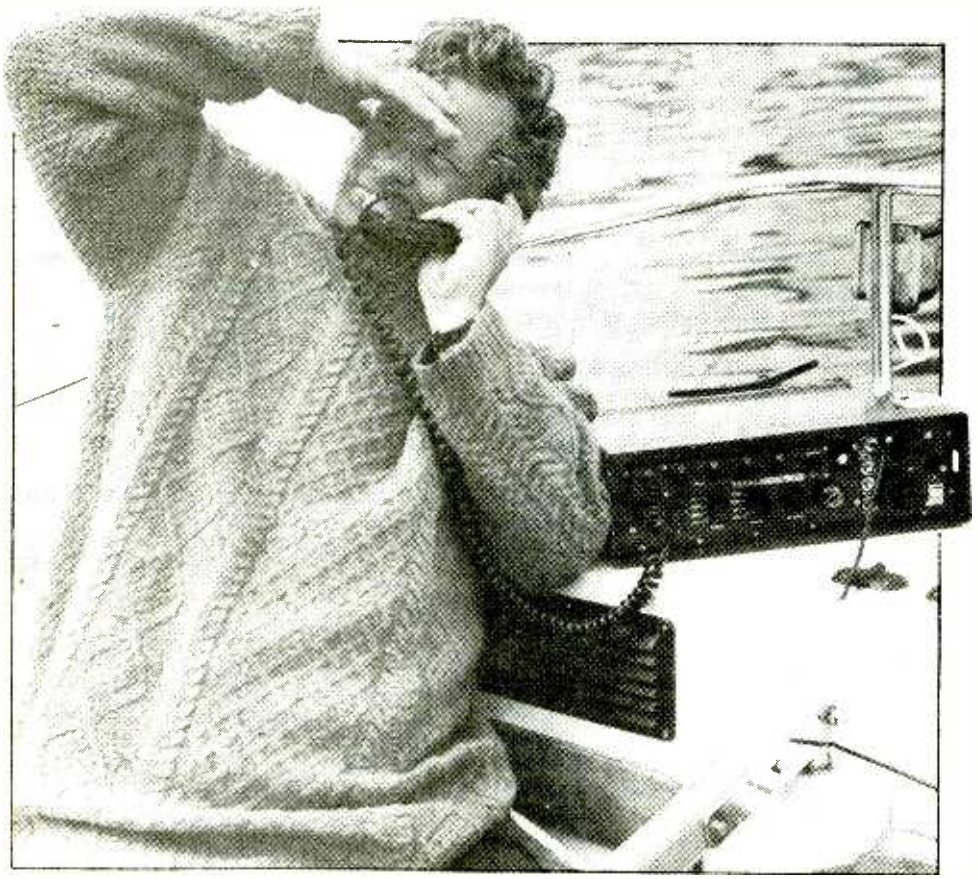
WW – 022 FOR FURTHER DETAILS

www.americanradiohistory.com

Program development with Occam

In advance of bringing out the Transputer, Inmos' advanced microprocessor, the company have launched development systems using their Occam language. The language has been available for nearly a year in an evaluation kit and has proved to be particularly useful for system designers, says Inmos, and so the 'system builders' workstation' has been developed with this in mind, giving some meaning to the phrase 'software engineering'. The language is based on the concepts of concurrency (doing different things at the same time) and communication. It is especially designed for use with multiple interconnected processors. Inmos claim that it is easy to understand, encourages structured programming with a syntax specially designed for interactive use. Many of the problems of programming microprocessors are solved with Occam by formalising the notions of input and output, interrupts, priorities and real-time. Using these eliminates the need to use real-time executives, or machine-code debugging. An Occam program by its nature reflects the structure of the application, describing how the hardware is arranged and providing the specification and implementation of each component. The formal structure of the language leads naturally to correct programs which may be transformed, preserving the function, much as logic functions may be transformed by Boolean algebra.

The workstation, based on a 16-bit 8088 processor, features 600K twin disk drives, 256K of memory, 800×400 pixel graphics. Software packages are available for the Sirius/Victor 9000 and for VAX/MMS computers. Further packages for the Intel iApX 8086, the Motorola M68000 and, of course, the Inmos Transputer, are planned.



Surely one of the good things about crossing the Atlantic single-handed would be to get away from the telephone. Not so for computer programmer Mike Spring who has taken a Racal radiotelephone to the Azores and back. It provided a link back home for weather information and emergency uses. Mike was paralysed from the waist down after a motoring accident and his voyage was to help to publicise a fund-raising campaign by the Pain Relief Foundation.

Shy computer firm comes out of the closet

Founded in 1977 at about the same time as Apple Computers, the American company Alpha Micro has depended on word-of-mouth recommendations for new customers. Although sales were steady, they did not have the meteoric rise of some other manufacturers (though they did get some good customers; NASA use them for their Automated Management Information Centre, a central data base system). All this changed with the appointment of a new chief executive, the company's president Richard Cortese. He suggested an aggressive approach to sales and marketing and (for example) a UK branch of the company has been opened.

Alpha Micro computers range from the AM-1000 desk-top business computer which can support seven terminals up to the AM-1092 which can accommodate over 40 users. They are all based on the M68000 processor and offer multi-tasking facilities. Software has played an important part in the development of the company and their own operating system, AMOS is claimed to be faster than Unix, although Unix may also be used, as can CP/M and a variety of programming languages. Alphawrite is a multi-user word processing system. Alpha Microsystems (UK) Ltd, 56 Herschel Street, Slough, Berks SL1 1PY.

www.americanradiohistory.com

End of the Newbrain?

The Newbrain microcomputer may have become one of the first casualties of the home computer boom following a decision by its manufacturers to go into liquidation. Grundy Business Systems, who bought the Newbrain design from Newbury Laboratories in 1981 have blamed 'severe cash-flow problems' – caused, it seems, by their attempts to expand production too quickly.

The Newbrain was designed at Sinclair Radionics by Sir Clive Sinclair; and on his departure to form his new company Sinclair Research the design was transferred to Newbury Laboratories. The machine was put on sale in May 1982 by Grundy after Newbury had decided to redirect their efforts into computer peripherals. Described at the time as 'the most powerful hand-held microcomputer in the world', the Newbrain had come close to being chosen by the BBC as the machine to accompany their television series on microcomputers; and although the BBC went on to adopt the Acorn machine instead, the Newbrain was soon selling, according to its makers, up to 5000 machines a month at a price of £199. The Newbrain, however, lacked some of the features which home computer buyers were coming to expect – such as sound output and colour and the availability of games software. Attempts by the makers to promote it as an economical machine for small business uses do not seem to have been enough to save it; nevertheless, Grundy hope to be able to find another buyer.

Ethernet wins one race

When Xerox developed Ethernet, the local area networking system, it was generally considered to be too late and not good enough to be accepted as a LAN standard. However IEEE study group 802 has presented its standardization proposals to the International Standard Organization. It is recommending a 'carrier sense multiple access with crash detection' (csma/cd) system which is closely based on Ethernet. This has been selected in preference to the 'token ring' (IBM) system and the wideband (Wang) system. Liason between the IEEE and the European Computer Manufacturers' Association to get a closer correspondence between the Ethernet-based standards adopted by both is to be carried out by Siemens.

News in brief

The Prime Minister is particularly pleased that there are now a million teletext tvs in UK homes. She pointed out at a recent conference that it is the most accessible information technology product and "paves the way for other new products based on the home tv set!" Also a healthy home market can lead to "a vigorous attack on overseas markets". A recent survey showed that 98% of all teletext and viewdata installations throughout the world use British technology.

- The Japanese video market has found a need to be able to examine the gaps in video tape magnetic heads so that they may be manufactured to the fine tolerances required. The size of the gap varies from 3 to 0.3 microns and the makers have found that they can see these best with microscopes made by Vickers Instruments, originally developed for use in semiconductor manufacture.
- Telephones for the hard of hearing work on the induction loop principle. However the latest generation of telephones cannot be inductively coupled to present hearing aids. In answer to a Parliamentary question, Under-secretary for Industry John Butcher has said that discussions with the Royal National Institute for the Deaf and the British Association for the Hard of Hearing are being held to find solutions so that the disabled people will also benefit from advances in technology. Provisions in the Telecommunications Bill will also protect the interests of the disabled.
- Amateur radio licensing has been transferred from the Radio Regulatory Division to the Post Office. The Post Office is to computerize the operation and it is prepared to guarantee a turn-round in normal conditions of five working days and at peak times of ten. The PO currently issues CB licences over the counter but all applications for radio amateurs' licences will be processed by post from the Post Office Headquarters in Chesterfield.
- Having attracted a number of 'high technology' companies to take space in their new Science Park, the University of Warwick suffers the embarrassment of not having any buildings ready until later in the year.

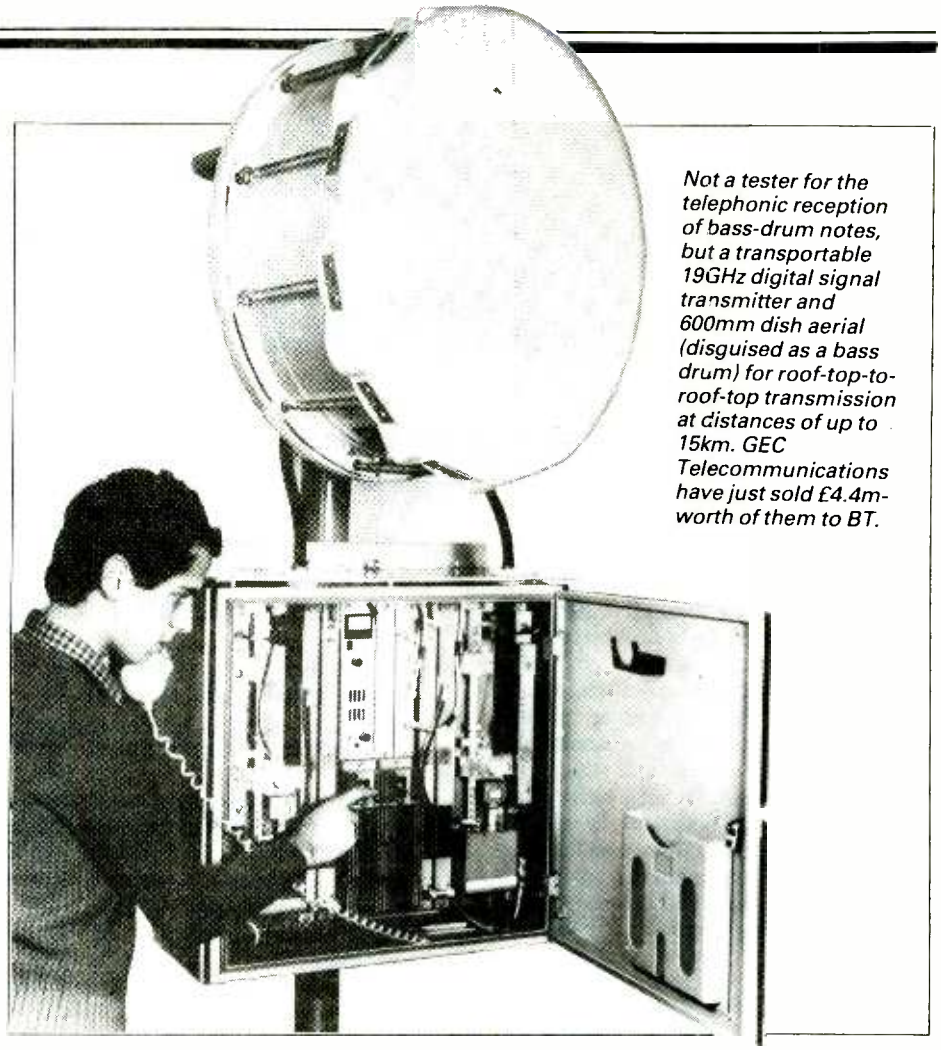
To overcome this, Warwick University is offering room in the academic buildings to four companies: Warwick Computer Designs, ABCO Technology, both in the microprocessor applications field, a surface coating company and a MIY Home Systems, who make a variety of devices for use in the home.

- John Alvey, the Chairman of the advisory committee on research into information technology, has been appointed Engineer-in-chief on the Board of British Telecom. He was formerly BT's Senior Director, Technology.
- The Youth Training Scheme is providing 700 young people throughout the UK with one-year courses in electronics, data processing or 'high technology office skills'. The scheme is to be managed by Control Data, through their training Institutes, at six different cities. The courses are to include 13 weeks of practical on-the-job training, a prerequisite of the YTS scheme, will take place in factories or offices near the Institutes which are biased towards computing or electronics.
- The pioneer in cheap micros, Sinclair's ZX81, is now being sold with a 16K rampack and a software cassette for £45, inclusive. This price makes it suitable for buying as a dedicated controller, for example, being less than some control devices or time clocks currently available.
- Transatlantic teleconferencing has become possible because of some techniques developed by BT at Martlesham. Although it has been possible to send tv pictures across the Atlantic, the link capacity required, equivalent to about 1000 telephone calls, has imposed excessive costs. The new digital service saves by sending only the changes in a picture and by using a new coder/decoder to send good quality pictures on digital links at 2Mbits/s, equivalent to 30 telephone calls.
- Unemployed engineers who have had experience in industrial research and development can apply for a Wolfson Industrial Research Fellowship. Applicants must propose a project that they will work on during the tenure of their Fellowship. There is no restriction on the projects chosen, except that each should show a reasonable expectation of commercial or industrial benefit in the medium term. Preference will be given to applicants in the age range 25 to 35 years. The scheme provides each research Fellow with a stipend appropriate to age and experience and to the laboratory where the research will be carried out to provide for overheads and expenses. Fellowship of Engineering, 2 Little Smith Street, London SW1P 3DL.
- A new British transistor manufacturer is soon to appear. Concentrating their efforts into testing and supplying semiconductors to BS and defence standards, Semelab in Lutterworth, Leicestershire also manufacture transistors from supplied wafers. They use stringent quality control tests to meet those same standards. A new factory has allowed them to expand their operation and they plan to get diffusion equipment to enable them to manufacture complete devices. One area that they aim to cover is discontinued transistors that the major companies can't be bothered to make any more but for which there is a continuing demand.

www.americanradiohistory.com

Multi-function multiplexer for light fibres

Faced with the problem of getting the same information as they were getting down 200 pairs of twisted copper wires and yet using optical fibres, the BBC has developed a flexible control system for switching audio, communications and control circuits through small cables. Fibre optics were chosen because they are unaffected by electro-magnetic interference and can be routed through conduit carrying mains power cables, if necessary. A master circuit at each end of a link allows 16 data channels to be routed through it. Each channel can carry up to 255 different coded commands giving a capacity of 4080 commands. Because the system is inter-active and two-way 2040 executive actions may be switched or remotely controlled. Different interface circuits may be plugged in to allow a circuit to perform specific functions; a two-way digital control interface allows commands to individual switches, indicators and remote control devices to be coded and sent over the system, an RS232 or RS422 interface allows the system to be used with any equipment using these interface protocols as in computer peripherals, printers and display units, an analogue interface provides eight send and return lines and is for use with remote variable analogue controls. The channel port itself conforms to the Centronics 8-bit parallel standard, which enables any system to be fitted to any combination of the available interface circuits. The design is to be marketed by Pilkington Fibre Optic Technologies Ltd, and their first customer is – of course – the BBC who have ordered 50 of the multiplexers for use in remote switching of tape machines in their local radio stations.



Not a tester for the telephonic reception of bass-drum notes, but a transportable 19GHz digital signal transmitter and 600mm dish aerial (disguised as a bass drum) for roof-top-to-roof-top transmission at distances of up to 15km. GEC Telecommunications have just sold £4.4m-worth of them to BT.

Satellite news

Several hundred million pounds are to be spent by Marisat for their next generation of marine communications satellites. These will replace the current programme with capacity leased on nine spacecraft, three of which are still to be launched. They are requesting tenders from satellite manufacturers from all over the world and stipulate that the craft should be capable of being launched from Ariane, the Space Shuttle or from the Soviet rocket, Proton. The system is to have more power and more capacity than the existing system; 125 telephone channels, compared with 40 on the Marecs satellite. Possible extension to the use of the system could be in aircraft communication which could add significantly to the efficiency of air-traffic control and as the satellites will play an important part in maritime safety and distress systems, they should be powerful enough to be able to relay distress calls from small transmitters as might be carried by a life-raft or emergency beacon. Another use mooted is for land communication to particularly isolated areas, though Inmarsat stress that maritime communication must have first priority. However, exactly such access has been granted to the Australian research base in Antarctica and to an Italian offshore drilling platform in the Adriatic Sea. These services will be used chiefly for the transmission of data to analysis centres.

The European large telecommunications satellite (L-Sat) has recently been re-christened Olympus and is likely to be launched from an Ariane 3 rocket late in 1986. This has been the subject of a contract between ESA and Arianespace. Another contract between them is for the launch of three satellites which are to be improved versions of Meteosat.

Brains trust for electronic brain research

Following the Alvey Report, five members of the Alvey programme steering committee have been appointed. They are Philip Hughes, chairman of Logica Holdings; Dr Keith Warren, director of technology and strategic planning at Plessey; Colin Southgate, chief executive, Thorn EMI Information Technology; John Leighfield, managing director, BL Systems, and Professor Eric Ash, head of the department of electronic and electrical engineering at UCL. Professor Ash will also represent SERC and Colin Fielding (Ministry of Defence) with Roy Croft from the DTI will complete the panel under the chairmanship of Sir Robert Telford.

The Committee has been set up to co-ordinate research in industry, academic centres, research organisation and the Government to "mobilise UK strength in advanced information technology". Four particular areas have been selected: very-large-scale integrated circuits, software engineering, intelligent knowledge-based systems (often called expert systems), and man/machine interfaces. Much of the work will be directed towards the development of 'fifth-generation' computers.

www.americanradiohistory.com

World timing using h.f. broadcasts

Using the apparatus described, and a versatile h.f. receiver, time signals of several h.f. stations have been found to be in error – some fast, some slow, some varying from day to day.

by R. C. V. Marcario and G. R. Munro

1983 is designated World Communications Year and one of its main objectives is to stimulate the development of improved communications infrastructures, most particularly in the developing countries. Often, improved communications means more rapid communications which implies good time keeping at all places. Even in everyday life, one now tends to time activities to the nearest minute, and the modern wristwatch can maintain this accuracy over a period of one year without resetting.

The common method of re-calibrating one's watch or time keeping device, is to use the hourly broadcast time signal, or a time information service on the fixed wired network. In each country the nation's master clock is controlled by a central bureau: in the UK we have the National Physical Laboratory, who maintain Greenwich Mean Time, as well as the other standards of time, e.g. UT, CAT.

Historically, GMT is the primary time standard of the world and there clearly would be no problem of having a uniform world time if the world need not be divided into twenty-four time zones (making the one mean solar day), and if GMT could be instantaneously and easily distributed. It is this last point that requries each country to have its own time bureau, and this is the matter of principal interest in this article. In practice, one can travel from nation to nation with a dependable master (atomic) clock and keep checking each bureau. Alternatively one can compare all the receivable time markers at one place on the earth, and after making due allowance for the time delay in a signal coming from a particular nation, check whether each bureau's clock has the same time (plus or minus the time zone hours differences).

Such a procedure is also important because frequency is the inverse of time and the clock at each bureau must of necessity be its standard of frequency. Errors of frequency can in fact be more of a nuisance than an error of time. For a full discussion of the relation between errors in time and frequency refer to reference 1. (For a valuable textbook on standards of frequency and time see ref. 2.)

It is common practice to indicate zone time by means of radio 'pips' or tones. In the UK the hour is marked by the beginning of the sixth of a set of five 100ms tones plus a sixth 500ms 1kHz tone. In many countries, one also has special standard frequency and time transmission, see reference 3. In the UK the 60kHz MSF Rugby transmitter, located at 52.35°N, 1.17°W, radiates a standard frequency, on/off modulated with coded one-second signals. This enables clock calibration to an accuracy of a few microseconds to be achieved over the UK (4).

Despite direct satellite broadcasting, the broadcasting of national news and views by means of short wave radio is as active today as ever. The World Radio & TV Handbook lists the frequencies and times of each nation's transmissions in an extensive manner, and indeed if one receives such signals the hourly time marker tones are often heard. One therefore has access to that particular nation's time bureau, except for the propagation delay. Fig. 1 illustrates the basic arrangement for comparing a local clock with a distant clock. With access to a number of hf receivers, multiple comparison can be arranged. This article describes some simple circuitry for setting up such an arrangement.

Comparison apparatus

Because of h.f. sound bradcast signals often being noisy, and also to more clearly separate the time marker tones from the programme material, a tunable bandpass filter, centred at say 1kHz is placed between the h.f. receiver's audio output and the signal recorder, as shown in Fig. 1. The most suitable signal recorder is a

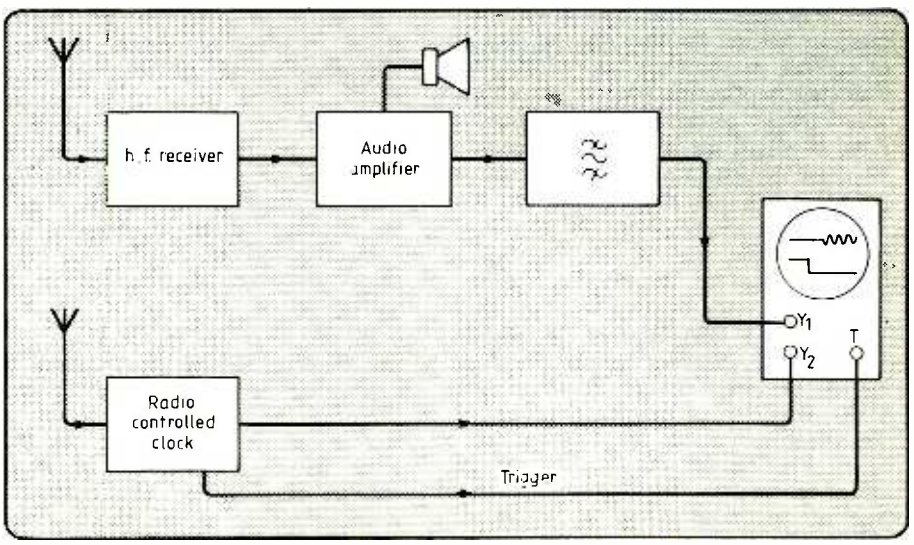


Fig. 1. Signal received on h.f. receiver is compared with a minute pulse marker generated from an MSF 60kHz receiver and displayed on a storage oscilloscope.

The authors are in the department of electrical and electronic engineering, University College of Swansea

www.americanradiohistory.com

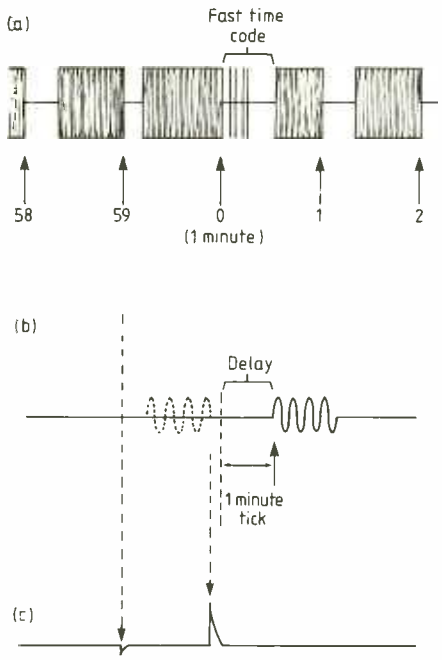


Fig. 2. Trace (a) in timing waveforms is part of the MSF signal format, but is not necessarily displayed: trace (b) is the style of the time pip tone received from an overseas h.f. station; trace (c) is generated within the MSF receiver and acts as the oscilloscope trigger pulse.

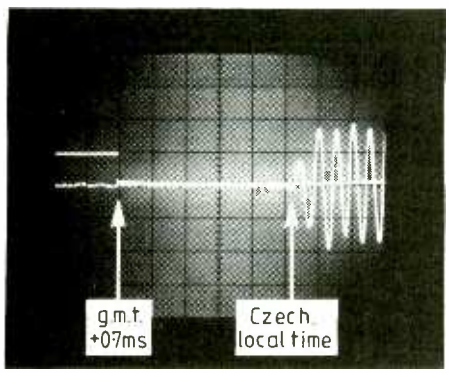


Fig. 3. Minute marker in this typical time comparison display is seen followed by the time tone waveform, from Radio Prague on 5.93MHz in the example shown at top. Time scale is 2ms/div. (09.15h 18 March 1983).

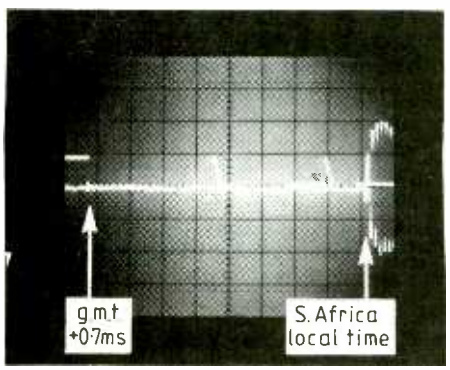


Fig. 7. Second time comparison display, bottom is over a distance of about 9250km, observed for Radio South Africa on 27.79MHz (14.00h 18 March 1983). Time scale 8ms/div.

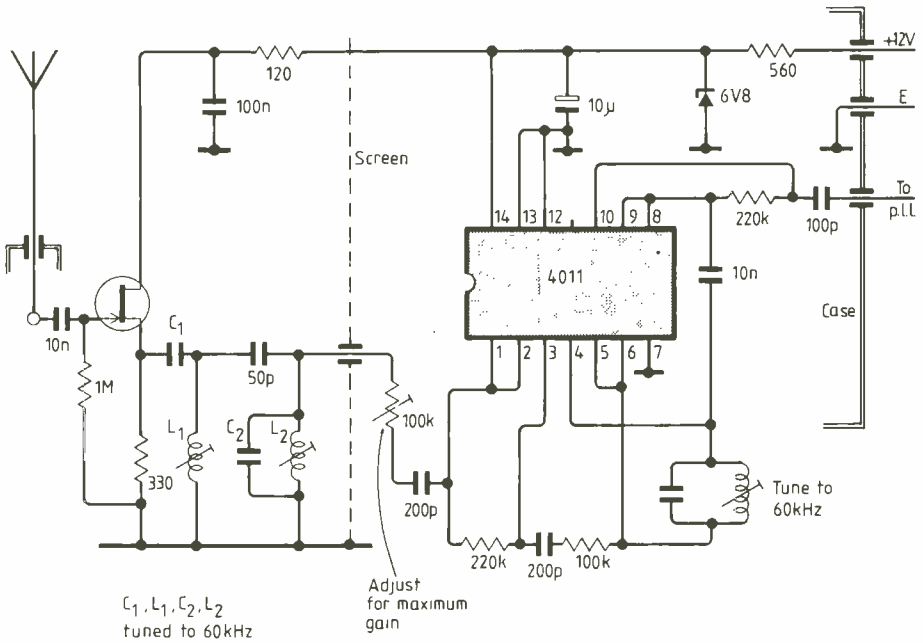


Fig. 4. Aerial amplifier for the 60kHz MSF signal. FET gives a high impedance input and so works off a short whip antenna. The cmos gates are operated in a linear mode and provide sufficient gain at 60Khz to drive a phase-locked loop detector, Fig. 5. This unit should be screened.

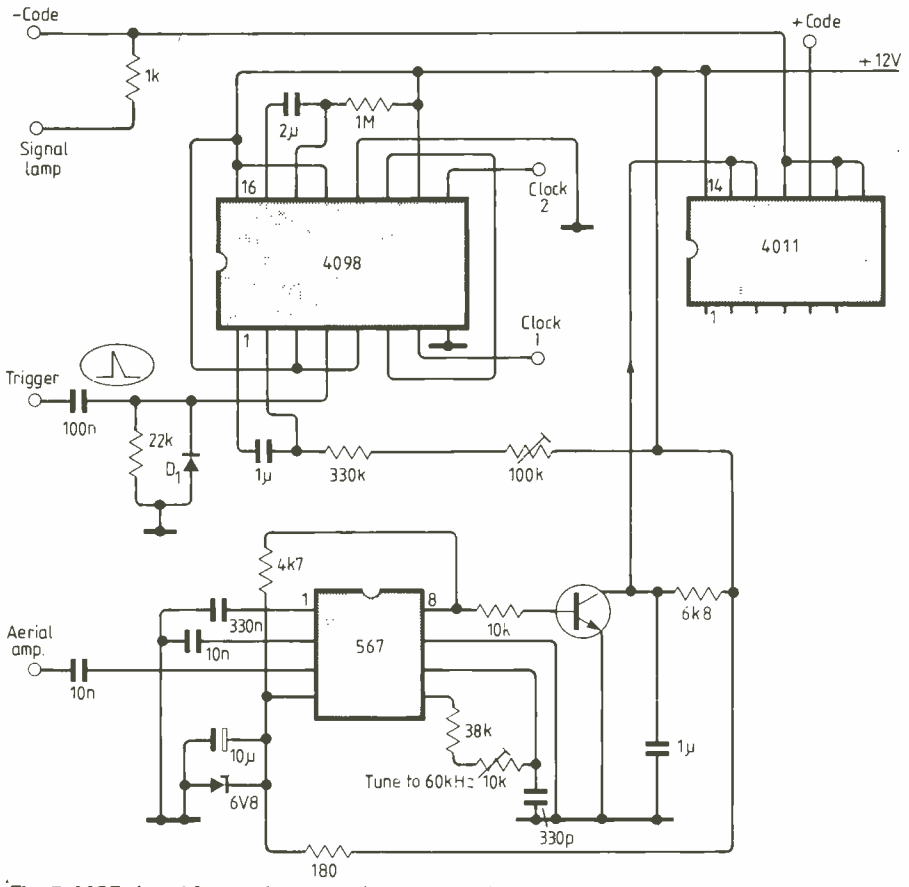


Fig. 5. MSF signal format is reconstituted from the 60kHz on/off carrier using the Signetics 567 tone detector. Output is raised to cmos level using 4011 gate. Trigger timing is set using a dual 4098 monostable.

storage oscilloscope because the time scale appropriate for the study is a few milliseconds. Examples of records are given below. In the other path is part of a receiver for the 60kHz MSF transmission and some logic for triggering the display on the minute on the hour, for example. One does not need to build a complete time-code receiver (5), just part, and an easily constructed system is described next.

That part of the MSF signal which occurs around the minute time is shown in Fig. 2(a). The slow time code information is distributed over the 60 second interval, each second occurring at the negative edge of these long pulses. After the 60th second a set of short pulses (10ms duration) constitute the fast time code. The edge of interest is the negative 60th second edge, which is displayed on the oscilloscope and gives the marker for GMT Fig. 2(b). The oscilloscope is required to trigger on the fifty-ninth second plus a suitable delay. Therefore the trigger circuit counts 58 pulses from the last trigger, and after a variable delay triggers the oscilloscope ahead of the one minute marker (c). The

www.americanradiohistory.com

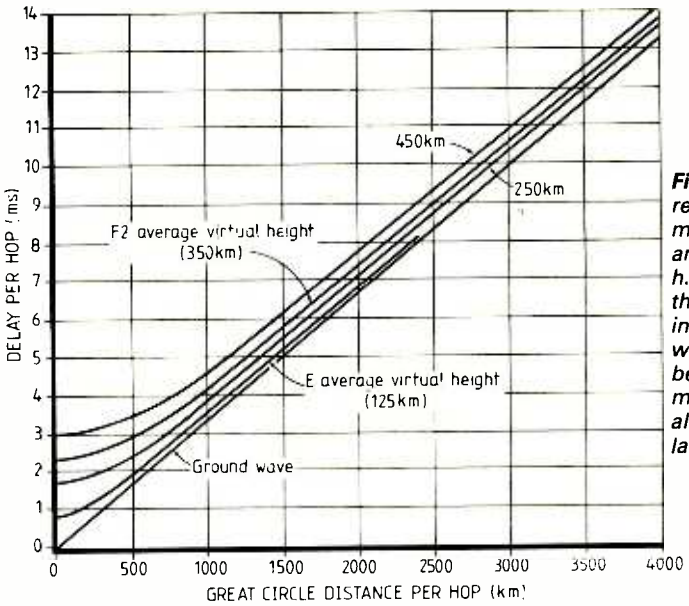


Fig. 6. Graph taken from reference 1 gives delay in milliseconds per hop for an ionospheric supported h.f. transmission, versus the great circle distance in kilometres. Delay time will vary during the day because the propagation may be supported by alternate ionospheric layers as indicated.

type of received time tone from the distant h.f. transmitter is shown at (d).

When these signals are combined together on the oscilloscope a pattern like Fig. 3 is observed. In this instance this was a time signal from Prague on 5930kHz at 21.30h UK time. The delay between the local g.m.t. and the received signal should correspond to the great circle path propagation delay, discussed below.

Trigger and timing circuit

A practical front-end circuit for receiving the MSF signal using a short-wire antenna is shown in Fig. 4. The circuit conveniently fits inside a standard Eddystone box. The f.e.t. provides a high input impedance, followed by a double-tuned circuit. Because linearity is not important for the receiver a cmos-linear amplifier using a feedback-coupled 4011 gate is used, providing a clean MSF signal carrier, except under very noisy signal conditions.

The carrier envelope contains the time information. The Signetics 567 p.l.l. time decoder will operate directly from the preamplifier, and a circuit is shown in Fig. 5. With buffering, a positive or negative code option at cmos level is available.

There are several options for triggering the display oscilloscope depending on how far one intends to make the system partially or fully automatic, because one needs to prime the trigger on the 58th second of the hour and have the 59th second produce a trigger pulse, delayed by about 990ms. We had the advantage of having a complete MSF time-code receiver and display and several options. The receiver would recognise the 59th second and give a delayed trigger pulse, using a 4098 monostable. The advantage of having a complete clock is that one now has a record of the time plus most of the required circuits already built; the type of display shown in Fig. 3 was therefore not difficult to arrange. To avoid further cmos circuitry we therefore leave the description of these circuits, as those already described set up the MSF code signal at cmos level (Fig. 2(a)) and one can arrange the required signal pattern according to any particular requirement.

Expected results

The negative edge marker is the local MSF GMT minute time, plus the propagation delay between Rugby and one's location. In our case NPL inform us that the delay is 695±2μs; allowing for some circuit delay, we therefore took the delay as being 0.7ms. The start of the distant station time marker (usually on the hour or the half hour) was assumed to be the first cycle peak of the received tone; therefore their local time would be the distance between the two marks, less the great circle h.f. path delay, plus 0.7ms. The h.f. path propagation delay would cause the distant station to appear later than the GMT marker, if its clock was on time.

The h.f. path delay can be estimated to within about ±0.5ms using the data from reference 1 shown as Fig. 6, assuming the great circle path distance can be calculated from a knowledge of one's own position and that of the distant transmitter. One does not know the transmitter's exact location, as an error of a few hundred kilometers will only produce a time delay error of, say, ±0.5ms (Fig. 6), which is not too important in some cases. The calculation of the path distances requires access to haversine tables (references 1 and 6) and a procedure is given in the Appendix.

Using the apparatus described and a versatile h.f. receiver one can collect interesting results. For example, Fig 3 showed Radio Prague, which is some 1350km distance, whilst Fig. 7 shows the recording for Radio South Africa on 27.790MHz, and distanced at 9250km. The delay on the received time tone is such that the first marker pulse of the MSF fast code can also be seen on the display.

We do not intend to discuss which stations have clocks running exactly in synchronism with GMT, as many results and careful calibration would be necessary. But we should say that several stations appear to be in error by orders of tens of milliseconds, some fast, some slow, some varying from day to day. A study on the basis of the method of national clock keeping would appear to fit in with the spirit of WCY83.

Appendix

Calculation of great circle distance

Require longitude of receiving and transmitting site, i.e. L_{OR} and L_{OT}, then let $L_{ORT}=L_R - L_T$. Require latitude of receiving and transmitting site, i.e. L_R and L_T. If the two locations are on the same side of the equator, let

$$L_{RT}=L_R - L_T$$

If the two locations are on the opposite sides of the equator, let

$$L_{RT}=L_R+L_T$$

Then the great circle distance (D) equation is

$$\text{hav } D=\cos L_R \cos L_T \text{hav } L_{ORT}+\text{hav } L_{RT}$$

where hav is haversine, from tables 1,6 and one second of arc is 1.853km.

The single hop mode delay, for distances less than 4000km, can be read off Fig. 6. For greater distances, a multihop model is required. This if distance is D(>4000km), and the number of hops is N(>2), then the total delay is

$$\Delta t=N \times \text{delay per distance } D/N$$

References

1. Frequency and Time Standards, Hewlett-Packard application note, AN52.
2. P. Kartaschoff, Frequency and Time, Academic Press 1978.
3. J. McA. Steele, Standard frequency transmissions, *Wireless World*, Sept. 1967, p.443.
4. Time and Frequency Service Notices, National Physical Laboratory, Teddington, Middx, TW11 0LW.
5. P. G. Giles, P. J. Hart, and I. Thomas, Radio clock for the reception and display of MSF time-code transmission, *Mullard Tech. Comm, No.140*, Oct. 1978, P.402.
6. D. A Moore. Basic Principles of Marine Navigation, Kandy Publications 1964.

LITERATURE RECEIVED

The new edition of the MS Components' Catalogue has increased considerably in size to reflect the addition of some 2,500 new products. A useful addition is the index to semiconductor i.c.s. MS Components Ltd, Zephyr House, Waring Street, West Norwood, London SE27 9LH.
WW 412

A 625-page hard cover book is needed to describe the full range of Wandel and Goltermann precision electronic measuring instruments. It includes details of a.f. and r.f. voltage and level generation and measuring equipment, analogue and digital data communications meters, distortion measurement, some general-purpose instruments and automatic measuring systems. Wandel and Goltermann, Postfach 45, Muhleweg 5, D-7412 Eningen, F.R.G.
WW 413

Interfacing the Real World to Your Computer is the title of a 16-page booklet which illustrates methods of interfacing sensors, transducers, output actuators and other devices. Products described include signal conditioners, two-wire transmission, alarm systems, analogue input/output sybsystems and remote, intelligent i/o subsystems. Analogue Devices Ltd, Central Avenue, East Molesey, Surrey KT8 0SN.
WW 414

More on p.48

www.americanradiohistory.com

CIRCUIT IDEAS

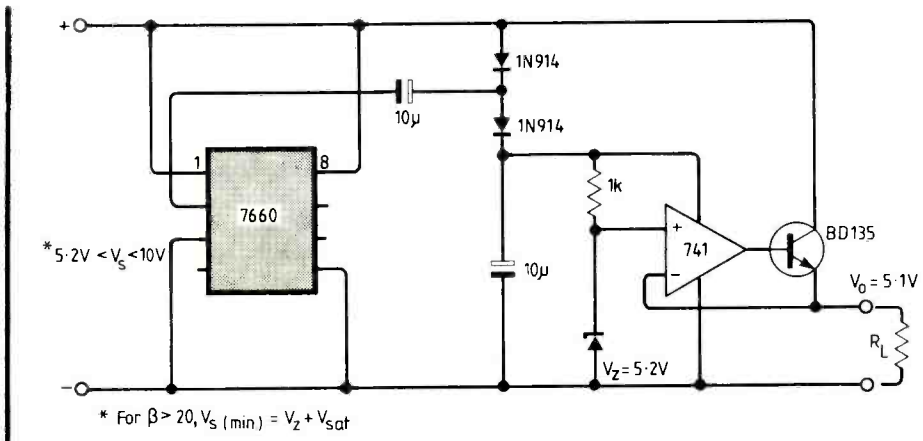
Multicharacter dot-matrix display

Designed as the display section of a terminal emulator for computer fault diagnosis, this expandable circuit drives a 16-character alphanumeric display from ASCII code. The four character Hewlett Packard HDSP2000 display is a seven-by-five dot-matrix type comparable in cost to 16-segment devices but it has constant-current l.e.d. drivers and is larger and easier to read. LCD modules with more functions exist but would limit the circuit to very low data rates. Electrically the display is a 28-stage first-in-first-out shift register with programmable constant-current l.e.d. drivers; character display is by external column strobing.

ASCII data may be asynchronous or read from ram addresses by the 7493 counter whose division factor n is equal to the number of display characters. Upper-case characters generated by the 74S262 are selected on lines B_{1-7} and converted to serial form by gating on each column output (shown abbreviated for clarity) while IC_1 cycles through row addresses n times. Display blanking occurs while data is clocked in. On completion of the character count the divide-by-n period signal goes low, triggering the 74121 monostable i.c. which stops the clock and unblanks the display for 2ms. After the pulse, column address counter IC_3 is incremented and the cycle repeats. Quinary counter IC_3 ensures that any random state at switch on synchronizes with $IC_{1,2}$ during the first count sequence. This method will not work with 2513 character generators which have no row address-zero output.

For flicker-free display each column must be strobed at at least 100Hz hence the choice of a 2ms display period; clock frequency determines the duty cycle by seven times the number of display characters. Component values shown drive a 16-character display.

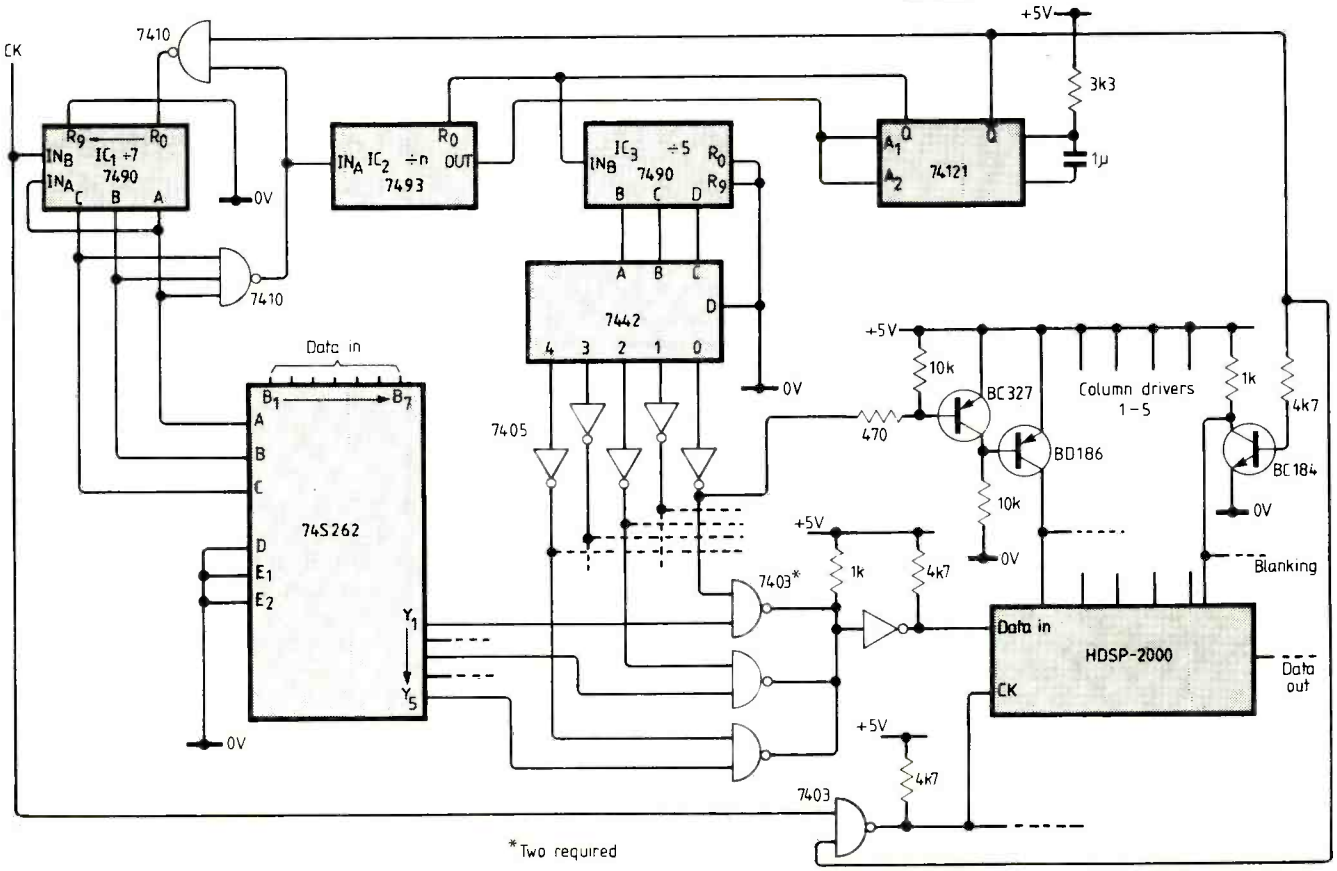
N. A. C. Simons
London W10



Regulator with negligible i/o voltage

When high or medium current is required from a voltage regulator, input/output voltage difference must usually be greater than 1V. Using a converter to increase the input voltage allows this differential to be reduced to the series-pass transistor saturation voltage. The basic circuit shown for a load of a few hundred mA can be used to provide a regulated 5V supply from a 6V battery. Ratings of the 7660 limit the input to below 10V.

A. Kerim Fahme
Autolight
Aleppo, Syria



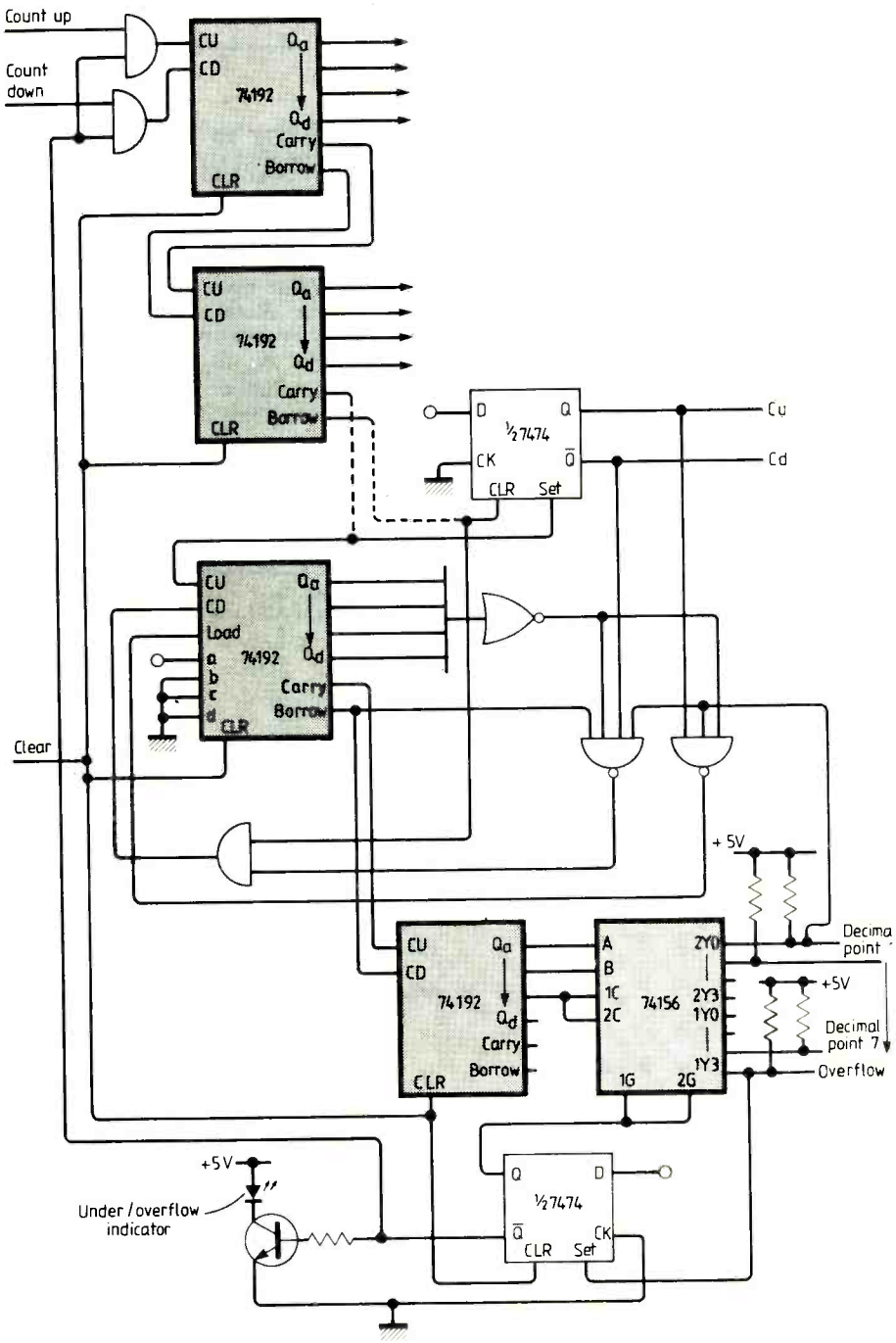
www.americanradiohistory.com

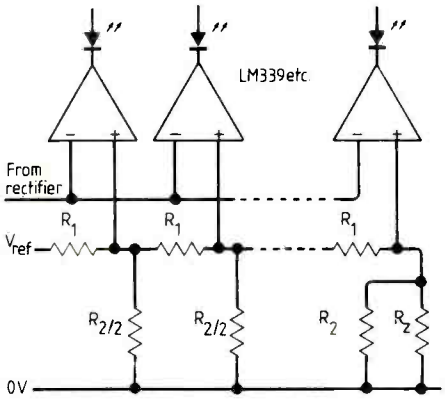
6-digit decade counter

This circuit for up to six digits counts up or down between .000000 and 999 999 and gives over and underflow indications. Positive edge transitions on the count-up line increment the least-significant digit and positive-edge transitions on the count-down line decrement the same digit. Buffered signals C_u and C_d represent carry and borrow indications respectively from the second most-significant digit.

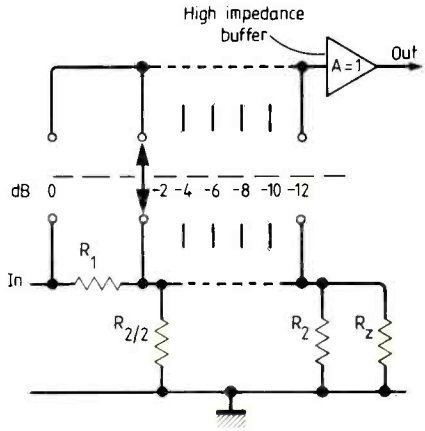
When the counter under or overflows the 74156 decimal-point, decoder 1Y3 output goes low, causing the under/overflow line to go high. This keeps C_u and C_d inputs of the lowest-order counter low and disables decimal-point decoder outputs. In this situation the counter is disabled and must be reset by the active-high clear input.

G. A. M. Labib
Cairo
Egypt





For 3dB steps: R_1 = 12k, $R_{2/2}$ = 100k, $R_2 // R_Z$ = 29k23



For 2dB steps: R_1 = 1k2, $R_{2/2}$ = 22k, $R_2 // R_Z$ = 4k53

Logarithmic dividers using equal resistors

These circuits, one a bar-display VU meter and the other a step attenuator, illustrate a logarithmic potential divider in which only the last section of the ladder, consisting of R_2 and R_Z in parallel, need contain a non-preferred resistor value. All other resistors in the ladder are one of two values. Where A is the voltage drop for each stage equations for values are as follows

$$(dB) = 20\log_{10}A$$

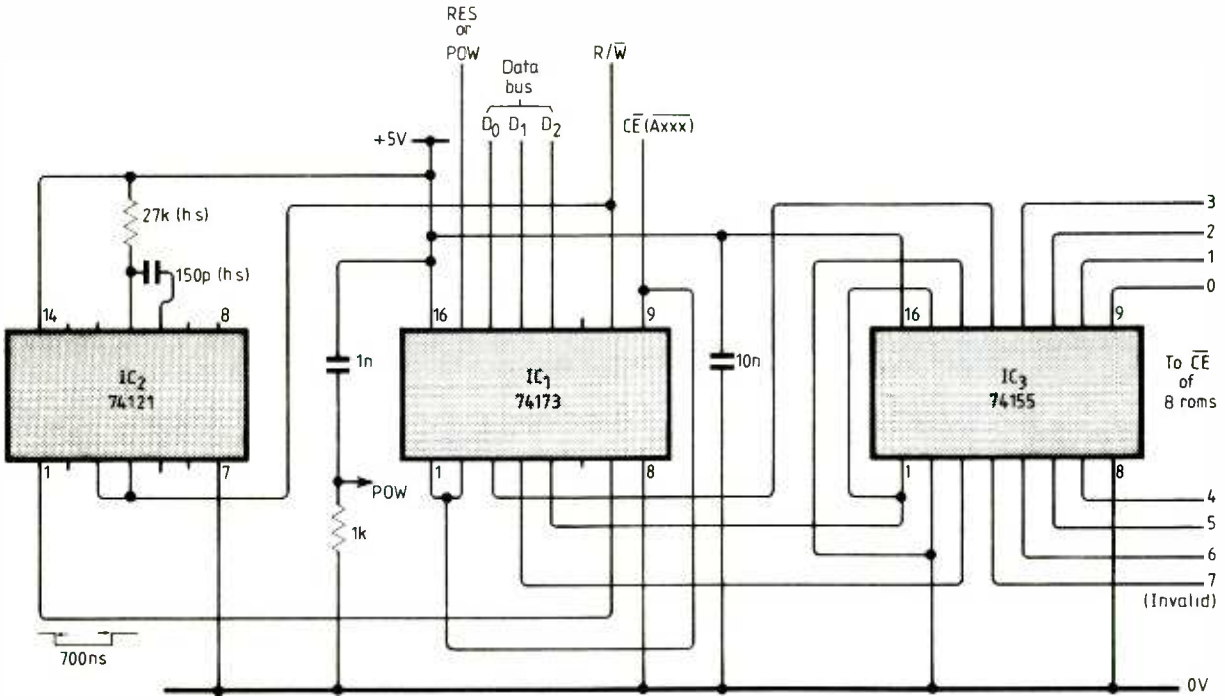
Z is the ladder impedance. As only one resistor is equal to Z it is better to choose either R_1 or $R_2/2$ as a standard value so that resistor packs may be used.

$$R_1 = \frac{Z(A^2-1)}{2A}$$

$$R_2 = \frac{Z(A+1)}{A-1}$$

John D. Thompson
Lewes
East Sussex

www.americanradiohistory.com



One-out-of-seven rom selector

Designed for the Acorn Atom which has only one spare rom socket though several roms are available, this circuit selects one rom from a possible total of seven by poking address $A000_{16}$ with the required rom number (0-7). Zero is automatically selected on power up (and reset if required) allowing a specific rom to be selected by default, e.g. a utility rom.

The circuit is based on the fact that a rom is never usually sent data from the processor. A write operation to the block Axxx is indicated by R/$\overline{W}$ and $\overline{CE}$ both being low; this is detected by the two enable inputs of IC_1 – a 74173 four-bit register which latches the data lines D_0, D_1 and D_2 to its outputs on a rising edge at its clock input.

Now R/$\overline{W}$ and $\overline{CE}$ are both set when the address lines are stable (ignoring propagation delays of about 50ns), however, the data is not present and stable for 650ns. IC_2, a 74121, is a monostable which provides a rising pulse 700ns after R/W goes low latching the data bus contents to the outputs of IC_1.

The latch outputs provide the input data for IC_3, a 74155, which is a dual 2-to-4 decoder configured as a 3-to-8 decoder (active low). IC_3 has a clear input which is active high and can be driven in one of two ways. Firstly it can be taken to RES giving a clear operation (sets decoder output 0 low) on any system resets including power up. However, remember that if the rom is part of the operating system (e.g. a utility rom) then system vectors will have to be changed before a new rom is selected. This can be overcome by using the second method, that is, clear on power up only ($\overline{POW}$). The system vectors can be reset by executing BREAK from the keyboard immediately after selecting a new rom. For example say rom 5 is wanted then:

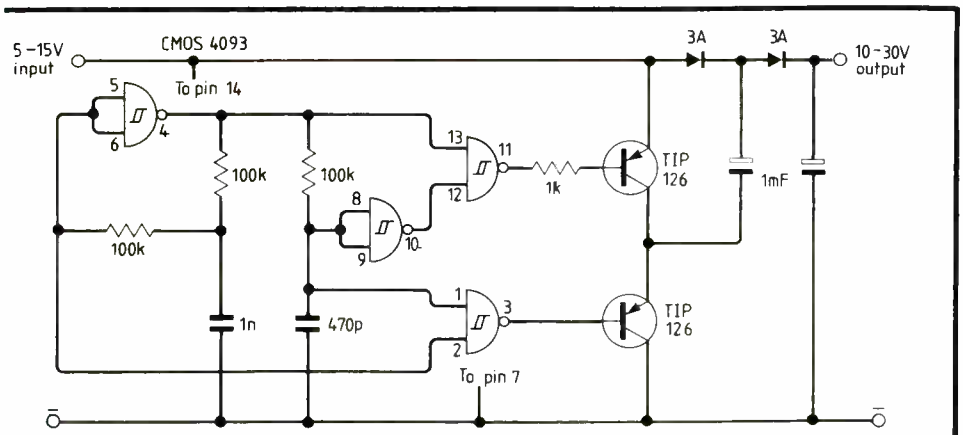
?#A000=5

is typed in direct mode followed by RETURN and BREAK. Any rom can be elected from within a program by:

?#A000=n(n=0, 1 . . . 7)

All the control lines required are available at the original rom socket (IC_{24}) with the exception of R/W which can be taken from b30 of p16. The circuit should work with any 1MHz 6502 processor.

D. C. Grindrod
Sutton Coldfield
West Midlands



4093 i.c., pin 14 to V_{in}, pin 7 to V-

Cheap voltage doubler

Originally designed to enable a 12V stack of NiCd cells to be charged from a 12V car supply without splitting the stack, this doubler can deliver around 2A depending on the type and value selected for the pump capacitor.

To prevent a large current flowing through the two output transistors during the transition period, a four-phase clock is used. The slave RC network has a 90 degree phase lead over the oscillator. The outputs of the slave RC network and the oscillator may thus be combined to produce non-overlapping output pulses. These pulses are fed direct to power Darlingtons which have sufficient gain for the power stage.

The pump capacitors actually require a value of only a few microfarads, but must be able to handle the currents involved. The cheapest solution is to use larger-value electrolytics.

Paul Stephenson
Hull

www.americanradiohistory.com

Improving stereo at l.f.

Spatial effect in a stereophonic sound system decreases at frequencies below 800Hz in comparison with a concert hall. This method for increasing the l.f. spatial impression of two-channel stereo reproduction can also be used to add ambience in mono reproduction.

by Y. Hirata

The spatial impression obtained when listening to sound in a room is related to the human biaural hearing property. When one hears sounds of the same amplitude and phase at both ears one, has no spatial impression and the sound image centres. On the other hand, hearing sounds of the same amplitude but several different phases at both ears, one has a spatial impression. The degree of spatial impression with steady-state random noise can be related directly to the interaural cross-correlation coefficient (i.c.c.), viz. the simple cross-correlation coefficient between sounds at both ears introduced by Damaske[1]. Curves of equal spatial impression using an i.c.c. depending on frequency of an applied random noise were given by Anazawa[2], but this measure cannot express well the difference between the spatial impression given by mono and stereo sound reproduction. In a room of reverberation time of more than 0.3s, there is no clear difference between the coefficients in mono and stereo sound fields. The spatial impression discussed here is the sort usually called ambience or 'surrounding sound' in audio.

The spatial sensations created by musical sound that involves many transient or pulsive sounds and steady-state random noise are different providing that the i.c.cs are the same, which is easily examined by experiments. Our hearing has an ability to locate a pulsive sound that is followed by many echoes of different incident angles. In other words, our hearing is less sensitive to early reflections that reinforce the direct sound[3]. Such a hearing property is important and should be reflected in quantifying spatial impressions for musical sound[4]. The rate of subjective intensity of a direct sound reinforced by early reflections is approximately given by the definition of Thiele[5] as the ratio of the energy of early reflections within 50ms, including the direct sound, to the total energy arriving at a given location in a room. We use this definition, D, tentatively as the weighting of the subjective intensity of a direct sound, and define the perceptual interaural cross-correlation coefficient (p.i.c.c.) by:

$$PICC = DR_0 + (1 - D)R_E \qquad (1)$$

where R_0 is the i.c.c. of the direct sound, unity for normal incidence, and R_E the i.c.c. of reverberant (incoherent) sounds, expressed by

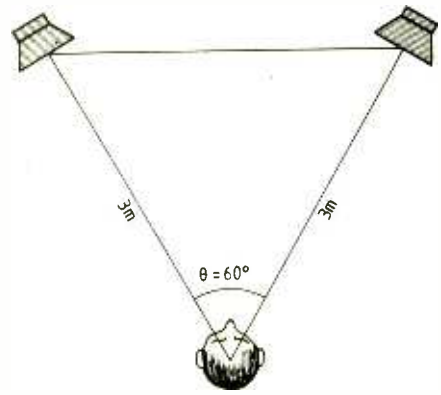


Fig. 2. Plan view of arrangement of loudspeakers and a listerner for compiling p.i.c.c. curves shown in Fig. 3 for stereo reproduction.

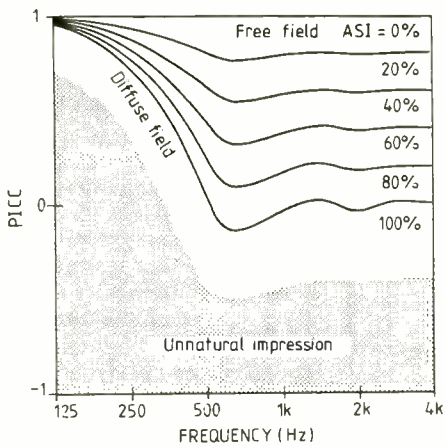


Fig. 1. Family of perceptual interaural cross-correlation (PICC) curves of equal acoustic spatial impression (ASI). Full spatial impression is indicated by ASI=100% and no impression by ASI=0% (below).

The author

Born in Tokyo, 1940, Yoshimutsu Hirata graduated from Waseda University in 1965 and received the degree of Dr Eng. by work on the acoustic property of mufflers with air flow in 1970. He was a researcher at Waseda University from 1970 to 1981, and from 1982, Dr Hirata became an independent researcher and consultant in the areas of room acoustics, noise control, electroacoustics, signal processing, and audio in general. A previous article investigating listening tests of amplifier sound in the October 1981 issue, described a new technique for quantifying amplifier sound using an asymmetric test signal with no d.c. component. We reported one of his earlier techniques back in 1974 when we met Dr Hirata at a London acoustics congress presenting a paper on multiplexing by digital comb filtering (News, October, 1974).

www.americanradiohistory.com

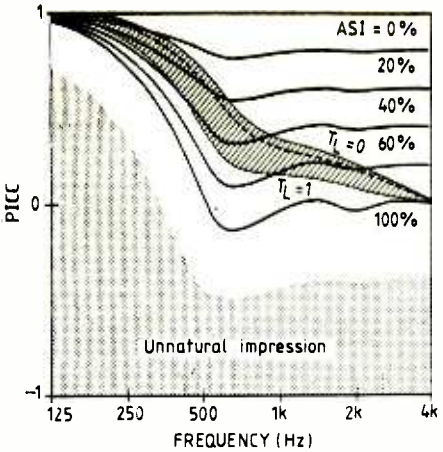


Fig. 3. PICC curves for stereo sound reproduction in a listening room of reverberation time O T_L 1s shows small ASI in low frequency band compared with an ASI=60% for the middle seat of a concert hall. Broken line shows T_L=0.3s.

$$R_E = \sin kr(f)/kr(f) \qquad (2)$$

where $k = 2\pi f/c$ is the wave number' c the speed of sound' and r(f) the acoustic distance between both ears, which is approximately 30cm[6,7]. Early reflections very close to a direct sound make a sound source appear somewhat more extended, which may be accounted for by the reduction of R_0. Such an effect, neglected here, should be given special consideration[8].

From equation 1, PICC = 1 for a single source in an anechoic room (free field) where D = 1, and PICC = R_E in a reverberation chamber (diffuse field) where D = 0. In an anechoic room one gets no spatial impression, while one gets full spatial impression in a diffuse field such as a reverberation chamber or stone cathedral which might have a reverberation time as long as 10 seconds. For convenience we introduce here ASI as the index of acoustic spatial impression, expressed by

$$ASI = (1 - D) \times 100\ (\%). \qquad (3)$$

Full spatial impression is indicated by ASI = 100% and no spatial impression by ASI = 0. Fig. 1 shows a family of p.i.c.c. curves depending on the frequency with ASI as parameter. The definition at a middle seat position in a concert hall is typically 0.4, where the p.i.c.c. is given by the curve indicated by ASI = 60%. Because one does not localize reverberant sounds, one gets the maximum ASI of 100% instantaneously at all seats in a hall for reverberant sounds heard, for example, at a rest after the stop of a *fortissimo*. Widespread plural sound sources of the same timbre also gives one a spatial impression, expressed by eqn 1, where the mean ICC value for plural direct sounds of several incidence angles is used for R_0. The grey area of Fig. 1 indicates the region where one gets a feeling of unnaturalness, viz. an excessive spatial impression or a separate impression when PICC approaches −1.

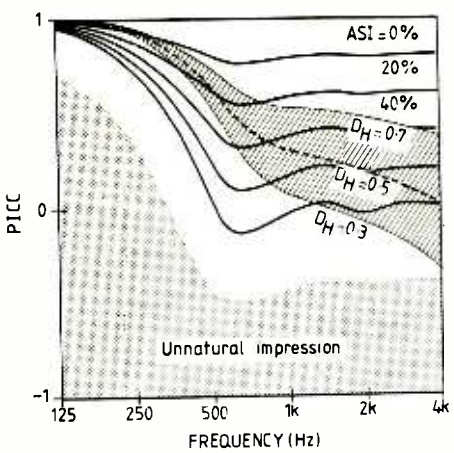


Fig. 5. Spatial impression of reproduced sound at low frequencies cannot be increased simply by reducing the recording source definition. PICC curves are for stereo sound reproduction where D_H = 0.3 implies too reverberant source and D_H = 0.7 too dry source. (Broken line shows the normal case of D_H = 0.5.) Reverberation time of listening room is T_L = 0.3s (a typical value).

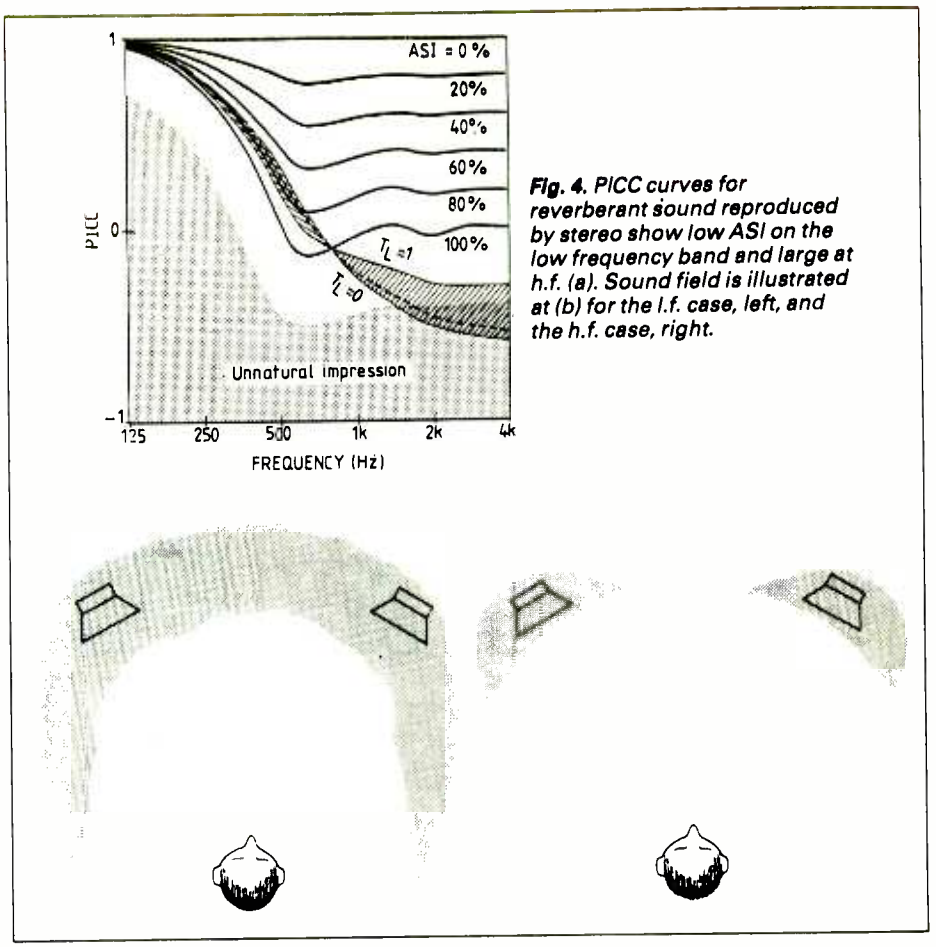


Fig. 4. PICC curves for reverberant sound reproduced by stereo show low ASI on the low frequency band and large at h.f. (a). Sound field is illustrated at (b) for the l.f. case, left, and the h.f. case, right.

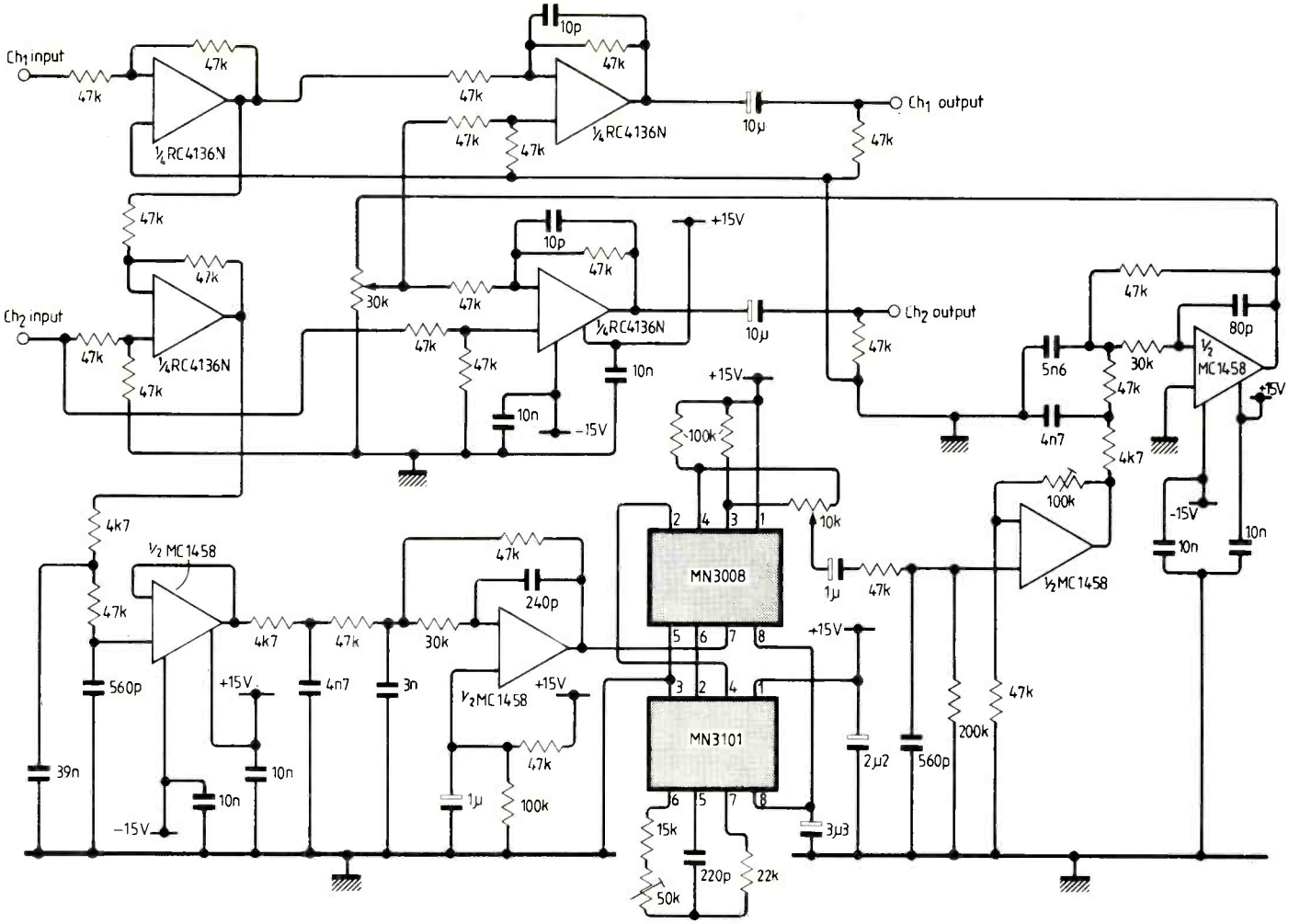
In a typical listening room of reverberation time 0.3s, the definition at a location 3m apart from a single source is about 0.9, where the p.i.c.c. is given by the curve indicated by ASI = 10%, assuming the reverberant sound is diffuse[9]. Thus, one gets but insufficient spatial impression for mono sound reproduction in a listening room. The p.i.c.c. for stereophony using two loudspeakers is

$$PICC = D_L R_{rep} + (1 - D_L)R_E \qquad (4)$$

where R_{rep} is the i.c.c. of the direct sounds emanating from two loudspeakers, which is a function of D_H, R_H, r(f) and θ, D_H being the definition of a recorded sound, R_H the cross-correlation coefficient between sounds recorded from two microphones placed at a distance from one another in a concert hall, and θ an angle at the listener of the configuration shown in Fig. 2. In the case of stereophonic recording, two microphones (or two sets of microphones) for picking up reverberant sounds in a concert hall are usually placed at a distance so that R_H = 0, which is empirically done by recording engineers. The typical value of the definition of a recorded source for symphonic music is 0.5, given by Yamamoto at NHK[10]. Using the values R_H = 0, D_H = 0.5 and θ = 60°, and assuming that the distance between a listening position and each loudspeaker is 3m, one gets the p.i.c.c. curves for stereo sound reproduction from eqn 4. The results are shown in Fig. 3 in the range $0 \leq T_L \leq 1$s, T_L being the reverberation time of a listening room, where a broken line shows T_L = 0.3s. Figure 3 shows that the ASI in the stereophonic sound field is small at frequencies less than 800Hz and large at frequencies greater than 800Hz in comparison with that in the concert hall, where ASI = 60%. The maximum spatial impression given instantaneously by the reverberant sound reproduced in a stereo system is expressed by the p.i.c.c. curve with R_H = 0, D_H = 0 and θ = 60° in eqn 4 and shown in Fig. 4. In comparison with the curve indicated by ASI = 100%, which is the maximum spatial impression given in the concert hall, the spatial impression for reverberant sounds reproduced by a stereo system is small at frequencies less than 800Hz. Fig. 4 also suggests that the reproduced reverberant h.f. sound gives an impression such as hearing two different reverberant sounds emanating from each loudspeaker.

Curves for stereo sound reproduction where the definition of a recorded source D_H is varied from 0.3 (too reverberant source) to 0.7 (too dry source) are shown in

www.americanradiohistory.com



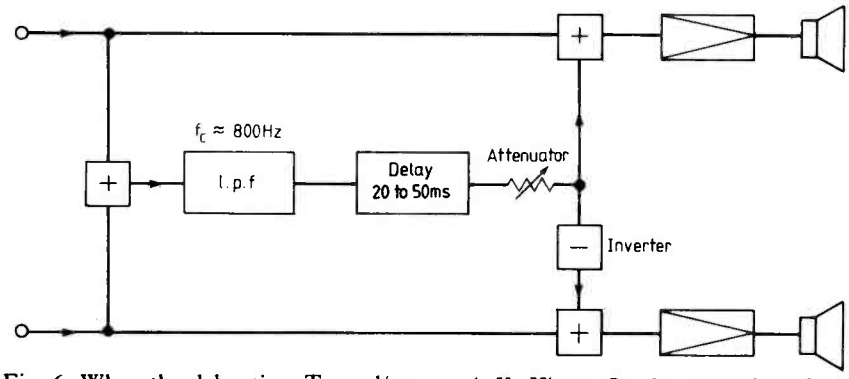


Fig. 6. *Block diagram of the circuit for increasing spaciousness for frequencies less than 800Hz. Delay line consists of an analogue shift register in the form of a bucket-brigade device. Delay time from b.b.d. is 45ms in circuit shown.*

Fig. 5, a broken line showing $D_H = 0.5$, and the reverberation time of a listening room is fixed at 0.3s. This indicates that one cannot fully increase the ASI of reproduced sound at low frequencies by simply reducing the definition of the recording source. To create natural spaciousness, one must decrease the p.i.c.c. at frequencies less than 800Hz and increase it at frequencies more than 800Hz. The p.i.c.c. decreases when the distance between two loudspeakers increases and vice versa.

One method for getting a natural spaciousness uses additional loudspeakers, some for low frequency and some for high frequency reproduction. But this brings the disadvantage (to a listener, an advantage to the maker) of spending money for the additional amplifier and loudspeaker system. To avoid increasing the number of loudspeakers, one can create natural spaciousness by using a simple circuit for decreasing the p.i.c.c. at low frequencies together with the geometrical method for increasing the p.i.c.c. at high frequencies. The block diagram of the circuit is shown in Fig. 6. When the delay time T_D and/or the magnitude of the delayed signal increases, the spatial impression increases, which is explained by the decreasing of the p.i.c.c.[11]. Incidentally, dropping the 'p' in p.i.c.c. makes this effect inexplicable, i.e. the i.c.c. remains unchanged for variable T_D.

The circuit of Fig. 6 is also available for adding ambience to the mono sound transmitted by a.m. radio or tv stations. This may bring up the basic question of whether a.m. or tv stereo broadcasting is really necessary.

References

1. P. Damaske, Subjektive Untersuchung von Schallfeldern, *Acustica* vol. 19, 1967/68, pp. 199-213.
2. T. Anazawa, H. Yanagawa and T. Itow, On correlation coefficients of both ears and the feeling of wideness, IECE Japan Tech. Rep. EA70-13, 1970.
3. H. Haas, Influence of a single echo on the audibility of speech (translation), *J.A.E.S.* vol. 20, 1972, pp. 146-59.
4. Y. Hirata, On the perception of acoustic space in reproduced sound fields, IECE Japan Tech. Rep. EA80-71 (1981).
5. R. Thiele, Richtungsverteilung und Zeitfolge der Schallrückwürfe in Räumen, *Acustica* vol. 3, 1953, pp. 291-302.
6. H. Yanagawa, H. Higashi and S. Mori, Interaural correlation coefficients of the dummy head and the feeling of wideness, A.S.J. Tech. Rep. H-35-1, 1976.
7. A. Suzuki and M. Tohyama, Interaural cross-correlation coefficient of Kemer head and torso simulator, IECE Japan, Tech. Rep. EA80-78, 1981.
8. M. Barron, Subjective effects of first reflections in a concert halls – the need for lateral reflections, *J. Sound and Vib.*, vol. 15, 1971, pp. 475-94.
9. Y. Hirata, Reverberation time of a listening room and the definition of reproduced sound, *Acustica* vol. 41, 1978, pp. 222-4.
10. T. Yamamoto and M. Nagata, Acoustical characteristics at microphone positions in music studios, *NHK Tech. Rep.*, vol. 22, 1970, pp. 475-89.
11. A. Miyashita, M. Wakamori, Y. Hirata and T. Itow, Spatial impression for transient sounds, A.S.J. Convention Rep. 1-6-3, 1983.

www.americanradiohistory.com

Problems in special relativity

Arguments that have been used to defend the special theory of relativity against criticism contain many inconsistencies. These problems should be thoroughly and objectively examined by scientists and philosophers to attempt to ascertain the truth of the matter.

Ever since Einstein's special theory of relativity became a prominent part of physics, it has been a subject of some controversy. One of the foremost critics of the theory was the late Herbert Dingle (1890-1978), who spent much of his time and energy during the last two decades of his life in trying to persuade the scientific world that the special theory, although mathematically valid, contains an inconsistency in its physical application. Although most scientists seem to be convinced that the controversy stirred up by Professor Dingle's criticisms has been conclusively settled in favour of the theory, a close examination of the relevant literature shows many inconsistencies in the arguments by which the special theory has been defended. The present article does not attempt to settle the matter; in fact it shows that the issue has not yet been satisfactorily settled. It is hoped that scientists and philosophers may be encouraged to continue the search for the truth of the matter, whatever it may be.

Simple example of inconsistency

Readers who are not experts on relativity may feel convinced that the inconsistencies that have been mentioned are beyond their understanding; on the contrary, many of them are perfectly obvious to anyone who takes the trouble to read them. To take a specific example, consider two inconsistent statements that were made in the British journal *The Listener* in 1971.

Professor J. Taylor claimed[1] that the results of the well-known experiment of Hafele and Keating, which had then been recently performed, supported Einstein's special theory. Professor Dingle published a letter rebutting Taylor's article, and further correspondence continued to be published, in the course of which another scientist, Professor M. A. Jaswon, published a letter[2] which disagreed with some of Dingle's points, but which agreed with Dingle that the experiment in question had "no relevance whatever for the special theory". Although that statement was directly contrary to Taylor's claim, Taylor later published another letter[3] which continued to criticise Dingle but which took no notice whatever of Jaswon's statement.

Professor McCausland is in the department of electrical engineering, University of Toronto, Ontario, Canada.

Some observers of the controversy may believe that inconsistent statements like these result from attempting to express abstruse technical matters in simple language, and that such inconsistencies may therefore be dismissed as being inconsequential. But the inconsistency between the statements mentioned above cannot be dismissed in that way. A statement that the

by Ian McCausland

results of a particular experiment support a certain theory is a perfectly simple factual statement (however abstruse may be the reasoning by which that statement is justified), and the same applies to the contrary statement. The fact that Taylor's and Jaswon's statements are contrary to one another (that is, they cannot both be true, though they could both be false) shows that, unless there is an inconsistency in the special theory itself, one or other of the two scientists (or both) misunderstood either the theory or the experiment (or both).

It will also be clear to any reader, scientist or not, who reads the whole of the correspondence that includes the above items (refs 1-3), that no attempt was made to resolve the inconsistency between Taylor's and Jaswon's statements. If science is the search for truth, wherever the search may lead, the serious inconsistency between the statements of the two scientists ought to be followed up to find out which statement, if either, is true. The fact that both statements have been accepted in spite of their obvious incompatibility is evidence that there is not enough scientific curiosity about the truth of the matter. The remainder of this article presents further evidence in support of the same point of view.

Further examples of inconsistency

Professor Dingle's criticisms of special relativity are presented at length in his book *Science at the Crossroads*[4], and it is in the published reviews of that book that many of the inconsistent attempts to defend the theory have been made. To study some of these attempts, consider Dingle's crucial question, which is central to his book, and which is worded as follows:

> "According to the special relativity theory, as expounded by Einstein in his original paper, two similar regularly-running clocks, A and B, in uniform relative motion must work at different rates. In mathematical terms, the intervals dt and dt′, which they record between the same two events are related by the Lorentz transformation, according to which $dt \neq dt'$. Hence one clock must work steadily at a slower rate than the other. The theory, however, provides no indication of which clock that is, and the question inevitably arises: How is the slower-working clock distinguished?"

In a review[5] of Dingle's book, Professor J. M. Ziman quoted the above question and then wrote: "This is a perfectly reasonable question to which science should indeed give an answer." Later in his review he gave his own answer, in the following words: "In fact, the answer to Dingle's 'question' is simple: the fastest-working clock between any two events is one that travels between them by free fall." But, as Dingle subsequently pointed out[6], neither of the events need be at either of the clocks concerned. Also, since the question asked for a distinction between two clocks, not for a choice among all possible clocks, Ziman's answer, whether or not it is a true statement, is simply not an answer to the question that was asked.

Dingle also supplemented his question by referring to a specific example in Einstein's original paper on special relativity, in which Einstein had stated that a balance-clock at the equator would work more slowly than an exactly similar clock at one of the poles. Dingle stipulated that any answer to his question should specify what it was that entitled Einstein to conclude, from the special theory, that the equatorial and not the polar clock worked more slowly. Dingle stressed that the special theory did not take any account of possible effects of acceleration, gravitation, or any difference at all between the two clocks except their state of uniform relative motion. It should be strongly emphasised, however, that he did not assert that acceleration and gravitation were *absent* from the situation described by Einstein, but that those phenomena are not dealt with by special relativity, and consequently it is not legitimate to invoke those phenomena to explain what entitled Einstein to conclude *from the special theory* that the equatorial clock worked more slowly.

The attempts to answer this supplemen-

www.americanradiohistory.com

tary question show an interesting diversity. In the first place, it is obvious that Ziman's answer, quoted above, does not apply to this situation; after the two clocks are in their positions at the pole and at the equator, there is no event at which both clocks are present, so there is no way in which Ziman's criterium can distinguish between them unless some pair of events is specified.

Consider now some of the other attempts to answer the question about the polar and equatorial clocks. For example, Professor G. J. Whitrow wrote as follows[7]:

> "For a supporter of relativity, the essential difference between the two clocks is that relative to the centre of the Earth (which for the purpose concerned can be regarded as the origin of an inertial frame) the clock at the equator describes a circle and so cannot be associated with an inertial frame, whereas the polar clock is at rest and can be associated with an inertial frame for a period of time during which the curvature of the Earth's orbit can be neglected. The time difference mentioned by Einstein can be demonstrated by means of the Minkowski diagram, in which the track of the polar clock will be rectilinear whereas that of the equatorial clock will be curved."

Two comments may be made about this. First, if the equatorial clock is not in an inertial frame, then its motion lies outside the scope of the special theory, which applies only to inertial frames[8]; it is therefore invalid to deduce from the special theory *any* conclusion about the relative rates of the two clocks. Second, the answer raises the equally difficult question of why a clock that moves in a large closed curve is in an inertial frame, while one that moves in a smaller closed curve is not.

Compare Whitrow's answer with the following answer, which is found in an unsigned editorial article in *Nature*[9]:

> "It seems now to be accepted that Einstein's original argument was uncharacteristically loose. The point of the illustration is that a clock at the pole of rotation may be taken to be in an inertial frame which is nearly (but not quite) properly defined by the direction of the Earth's motion around the Sun. The clock at the equator is in another. Einstein's lack of clarity concerns the inertial frame of the observer of the two clocks."

This statement implies that the answer to the question about which clock works more slowly depends on the observer. But Einstein's statement clearly implies that the slowing of the equatorial clock is a real effect and not merely an effect of observation, and this is confirmed by the fact that he added a footnote to say that his statement did not apply to pendulum clocks[10]. The answer[9] also states that the equatorial clock is in an inertial frame, and this explicitly contradicts Whitrow[7], who states that it is not.

Another answer to the same question is given by Stadlen[11], who writes:

> "But the relative motion involved in this case, being circular, is non-uniform. I submit, therefore, that Einstein was wrong in saying that his prediction followed from the special theory, which deals only with the effects of uniform motion. This is not to say that the prediction was invalid. For Einstein was, intuitively, anticipating his later general theory, according to which the equatorial clock runs slower because of the centripetal force exerted upon it."

This answer is inconsistent with *both* the previous answers, since it disagrees with Whitrow[7] about whether the result follows from the special theory, and it disagrees with the *Nature* editorial[9] about whether the slower working is real or dependent on the motion of the observer. Furthermore, the fact that the prediction follows from the general theory does not make Einstein's prediction *from the special theory* valid, as Stadlen implies it does. As is well known to logicians, the fact that the conclusion of an argument is true does not guarantee that that argument is valid.

Another interesting attempt to identify a false step in one of Dingle's arguments was made by McCrea[12], who wrote:

> "The false step is that Dingle regards the situation treated by relativity as the symmetric comparison of one single clock with another identical single clock (in relative motion). This is not the situation. Actually many colleagues have pointed this out, or given an equivalent answer."

Unfortunately McCrea does not identify any of the "many colleagues" whom he claims to support his argument, but it is clear from the foregoing that Ziman, for example, does not. Ziman states[5] that Dingle's question is perfectly reasonable, and the question, as he correctly quoted it, includes a statement that if there are two clocks in uniform relative motion, the special theory requires one to work steadily at a slower rate than the other. McCrea's statement is also inconsistent with Einstein's statement that a (single) clock at the equator would work more slowly than an exactly similar (single) clock at one of the poles.

Other illogical arguments

In addition to the inconsistencies already mentioned, some of the arguments used in defending special relativity are lacking in logical rigour. To illustrate this, consider some examples.

In one of the earliest attempts to refute Dingle's criticisms, Born[13] wrote as follows:

> "The simple fact that all relations between space co-ordinates and time expressed by the Lorentz transformation can be represented geometrically by Minkowski diagrams should suffice to show that there can be no logical contradiction in the theory."

As the Lorentz transformation is contained in the special theory, but is not the whole theory, it is not logically valid to claim that some property of the Lorentz transformation is a sufficient condition for the whole theory to be free of logical contradiction.

In another attempt to refute Dingle, Professor I. Roxburgh[14] discusses Dingle's argument that if there are two clocks A and B in uniform relative motion, the special theory requires A to work faster than B and B to work faster than A, and this makes the theory internally inconsistent. Roxburgh states that Dingle does not even discuss what he means by "faster", and then goes on to say:

> "Secondly, why is it impossible for A to go faster than B and B to go faster than A? This depends on the definition of faster. To illustrate this, consider the following two statements:
>
> The moon is bigger than the sun.
> The sun is bigger than the moon.
>
> Are these statements mutually contradictory? This depends on the meaning of bigger. For terrestrial beings the first statement is true, for Martians the second is true. The relative size depends upon the position of the observer. So it is with time and clocks."

If it is important to define "faster", it is also important to use other words precisely; yet it is clear from the quotation that Roxburgh does not literally mean "is" in the two contrasted statements, but something like "appears to be". Thus, the two contrasted statements are not analogous to the two statements that Dingle claims to be inconsistent. Or, if Roxburgh does mean the pair of contrasted statements to be taken literally, then he, as a terrestrial being, is asserting that the moon is bigger than the sun. Although we are terrestrial beings, we know that the sun is bigger than the moon, and we know it from observations that have been made from the earth.

To put the matter in terms of logical relations, the expression "is bigger than" represents an asymmetrical relation, whereas Roxburgh's pair of contrasted statements asserts that "is bigger than" is not an asymmetrical relation[15]; there is therefore a contradiction inherent in what Roxburgh has written. Of course, a contradiction between any two statements can be avoided if one is free to disregard literal meanings of words and interpret the meanings of the statements in such a way as to avoid the contradiction. This is similar to the technique described by Dingle (ref 4, page 180) for avoiding the inconsistency in special relativity: "When the theory appears to lead to incompatible objective results, they are written off as merely different *appearances*, but claimed as *realities* when some actual phenomenon has to be explained."

Whitrow has also published an argument[7] which purports to refute Dingle's claim that the special theory is inconsistent in requiring each of two relatively moving clocks to work faster than the other. The last sentence of his argument is:

> "Dingle's requirement is therefore equivalent to introducing the Newtonian concept of universal time, and this is incompatible with special relativity."

Now whether or not Whitrow's statement about Newtonian time is true, the sentence quoted does not prove that Dingle is wrong; all it states is that either Dingle is

www.americanradiohistory.com

wrong or special relativity is wrong. As the point at issue is the validity of special relativity, and as the context obviously implies that the argument that ends with the quoted sentence proves that Dingle is wrong, Whitrow's argument shows an excellent example of the textbook fallacy known as begging the question[16]. Since Whitrow has subsequently published the same argument two more times[17,18], in obituary notices on Professor Dingle, the pointing out of this logical fallacy is overdue.

The foregoing examples of inconsistencies and logical fallacies in the arguments used to defend special relativity do not in themselves prove that Dingle is right, or that special relativity is wrong. However, if two scientists make inconsistent statements about the same theory, one or other of them must have made an error in deduction, or else the theory itself contains an inconsistency. In other words, the inconsistencies in the statements that have been made by the defenders of the special theory actually support Dingle's case that there is an inconsistency in the theory, rather than refuting it.

Although scientists may be convinced that the conclusion they have already reached is true, they should also be concerned with whether the arguments by which that conclusion has been reached can withstand scrutiny without revealing inconsistencies. I suggest that the scientific ideal toward which science should strive in this case is that stated by T. H. Huxley when he wrote[19] that "the scientific spirit is of more value than its products, and irrationally held truths may be more harmful than reasoned errors." It is time for the truth of this matter to be actively and carefully sought.

References

1. J. Taylor, Views, *The Listener*, vol.86, 1971 p.6423.
2. M. A. Jaswon, Travelling clocks. *The Listener*, vol.86, 1971, p.724.
3. J. Taylor, Travelling clocks. *The Listener*, vol.86, 1971. p.804.
4 H. Dingle, Science at the Crossroads. Martin Brain & O'Keeffe, London, 1972.
5. J. Ziman, Science in an eccentric mirror, *Nature*, vcl.241, 1973, p.1434.
6. H. Dingle, Dingle's question, *Nature*, vol.242, 1973, p423.
7. G. J. Whitrow, Review of "Science at the Crossroads", *British Journal for the Philosophy of Science*, vol.26, 1975, pp.358-62.
8. A. Einstein and L. Infeld, Evolution of Physics, Cambridge University Press, 1938.
9. "Dingle's answer" (unsigned editorial) *Nature*, vol.239, 1972, p.242.
10. A. Einstein, On the electrodynamics of moving bodies, in H. A. Lorentz *et all*, The Principle of Relativity, Methuen, 1923; Dover, 1952.
11. G. Stadlen, "Dingle's challenge", *The Listener*, vol.88, 1972, pp.411/2.
12. W. H. McCrea, Definitions and realities, *The Listener*, vol.82, 1969, p.315.
13. M. Born, Special theory of relativity, *Nature*, vol.197, 1963, p.1287.
14. I. Roxburgh, Is special relativity right or wrong?, *New Scientist*, vol.55, 1972, p.602.
15. I. M. Copi, Symbolic Logic, fifth edition, Macmillan, New York, 1979.
16. I. M. Copi, Introduction to Logic, fifth edition, Macmillan, New York, 1978.
17. G. J. Whitrow, "Herbert Dingle", *Nature*, vol.277, 1979, pp.584/5.
18. G. J. Whitrow, "Herbert Dingle", *Quarterly Journal of the Royal Astronomical Society*, vol.21, 1980, pp333-7.
19. T. H. Huxley, The coming of age of 'The origin of species', in Collected essays, vol.2, Mcmillan, 1894.

Ian McCausland holds the degrees of B.Sc. and M.Sc. in electrical engineering from Queen's University of Belfast, Ph.D. in electrical engineering from the University of Toronto, and Ph.D. in control engineering from Churchill College, Cambridge. He is the author of a book "Introduction to Optimal Control" (Wiley, 1969). He is now at the University of Toronto, where he is a Professor in the Department of Electrical Engineering and a part-time undergraduate in the Faculty of Arts and Science.

Next month

Richard Lambley describes the Wireless World NiCd Battery Charger, capable of recharging cells of all common sizes in about an hour. Up to 15 cells in series can be charged at once and there is an unusual shutdown circuit to prevent overcharging. For maximum efficiency, the charging current is delivered from a switch-mode source.

Ron Slater investigates career possibilities for electronic engineers. Training, qualification requirements, salary to be expected and the areas of the country where jobs are on offer are all considered by Mr Slater, who has a great deal of experience in finding work for engineers.

David Taylor-Lewis presents a versatile tone-burst gate, which provides an integral number of on and off cycles, each adjustable from 1 to 9999. It will also give a variable duty cycle square wave between 1:9999 and 999:1 and pulse bursts or gaps from one trigger.

Philip Barker describes a method of using a computer, a video disc player and a television receiver to construct an interactive information display system for education, training or archival purposes.

On sale October 19

www.americanradiohistory.com

Using a micro to process 30 line Baird television recordings

Early television recordings on gramophone records – Phonovision – were crude in the extreme. The author describes a method for improving picture quality by correlation and digital filtering

by D. F. McLean
B.Sc. (Hons)

In the late 1920's, J. L. Baird performed some experiments on the recording of television pictures onto wax discs.* This he called 'Phonovision' and for a time caught the imagination of the prospective viewing public with this and other television-related inventions. Surprisingly few of these early recordings are still in existence.

It is hoped that this article will allow people to 'look back' to those early television pictures and will show that the old and the new technologies can be brought together by anyone having access to tape copies of the recordings and a personal computer.

The requirements for the computer are not strict. A minimum specification would include sufficient memory for a long sequence of frames, some sort of graphics capability allowing the pictures to be displayed with a few grey levels, an analogue-to-digital converter and a sampling clock for the converter and the computer. In my case, there is enough memory for 32 frames at less than 1Kbyte per frame and a converter capable of sampling at 15kHz to 8bits of accuracy (256 levels of voltage) under control of the computer and the sampling clock. For more detailed pictures either the sampling rate can be increased or the playback speed of the recording decreased.

Although the author had known about mechanical television for some time, it was only comparatively recently that examples were first heard on a BBC documentary record. Out of interest, I decided to display the sounds on this record as images, using a computer, as it was able to store the pictures as a sequence of samples. These pictures could be 'replayed' over and over again to check for movement, features and details. The replay was viewed on a graphics display, but an oscilloscope with control of X,Y,Z modulation by the computer would have been just as good.

It was clear from the start of these experiments that there were no synchronization pulses for identification of the start of lines and frames: the frames appeared to roll and drift in position due to playback speed variations. Synchronization of the early disc recordings was obtained by having the record platter rotation directly linked through a gearing arrangement to the scanning apparatus – figs. 4 and 5 show this arrangement clearly. The more common recordings of the mid 1930's were not linked in this way and relied on the record platter inertia to reduce picture 'hunting' or slippage.

If the original synchronous recordings had been available for these experiments a sampling clock for the computer could have been derived from the rotation of the record player, to ensure synchronization independent of playback speed. In their absence, I have evolved a method for re-aligning the sequences of pictures and inserting new synchronizing pulses, in an attempt to get nearer to re-creating the original scene quality.

30 line Baird standard

In a similar fashion to broadcast television today, the 30 line picture was created by scanning a spot of light of varying brightness in a particular pattern to form the display area. To re-create the scene as recorded, the spot had to follow this raster pattern exactly in synchronism with the video signal. If exact synchronization was not maintained, the picture would roll or slip in a similar fashion to an out-of-adjustment 'vertical hold' control on a modern tv receiver. Modern tv standards include provision for sync. pulses to 'tell' the receiver where the start of line and frame is: hence picture slippage is rarely a problem. A form of sync. on 30 line transmissions was obtained from a mixture of the inertia of the scanning disc and the actual scene content (as the television waveform was used to control the disc's rotational speed). Synchronizing the transmitter and receiver to mains frequency was only successful within the area served by a particular generator.

The scanning action on Baird 'Televisor' types of receiver was performed by a rapidly spinning disc which had a spiral pattern of holes spaced at equal angles around

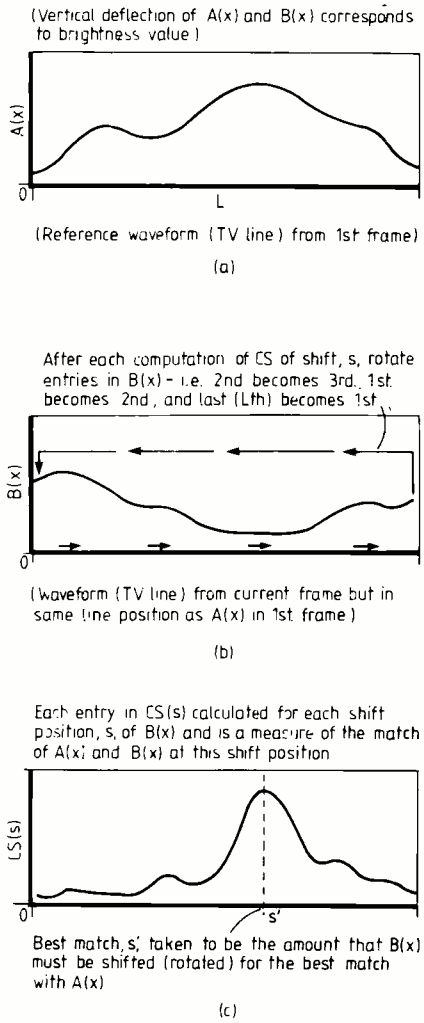


***Fig. 1.** Line matching. First two waveforms are reference and line to be matched by shifting. Samples of A multiplied by B samples produce 'score' at (c).*

*See references 1-6 for details of 'Phonovision'.

www.americanradiohistory.com

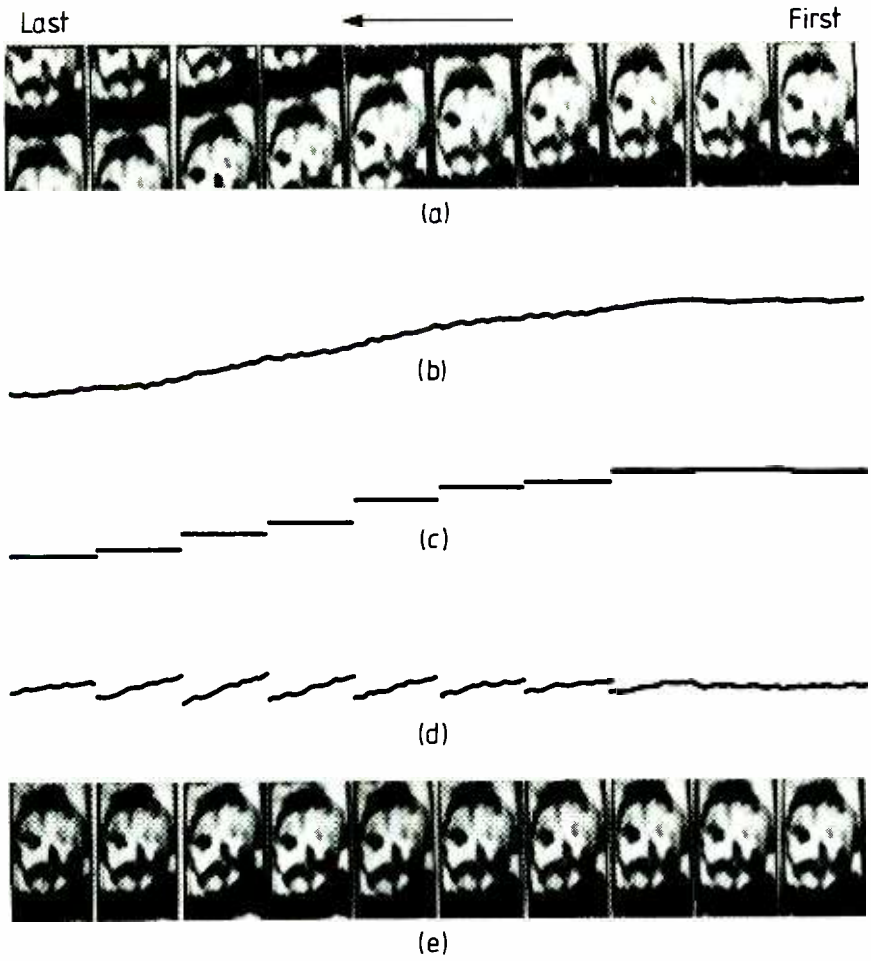


Fig. 2. Performance of one-dimensional line-matching system.

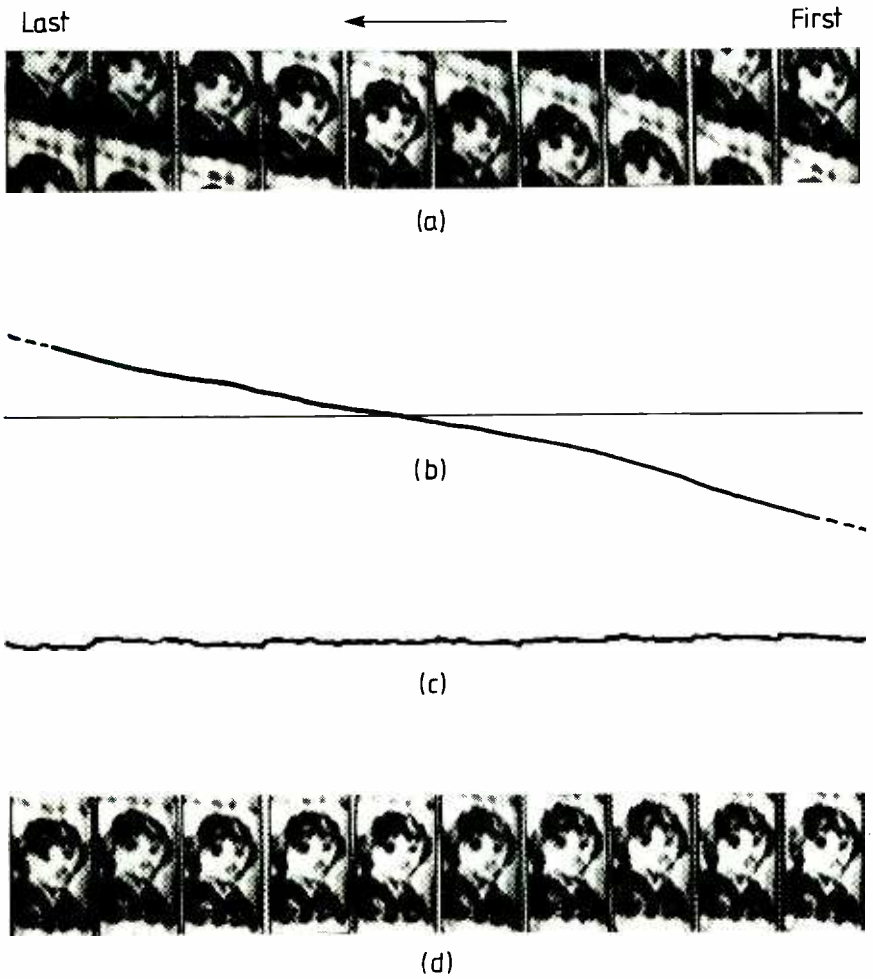


Fig. 3. Linear interpolation between adjacent frames instead of single-value shift of Fig. 2 (c). Picture tilt in each frame of (a) and removed at (d).

the disc, to give a small display area with a height-to-width ratio of 7:3. The frame or picture repetition rate was 12½Hz, each frame being made up of 30 lines. The spot of light that built up the raster scanned vertically from bottom to top to build up one line, each new line being placed slightly to the left of the previous line until a total of 30 had been scanned. The spot then returned to the position of the first line to start the next frame.

Correction of picture drift

In many applications of signal processing, the correlation or matching technique has grown in use throughout the years to become today a very powerful tool. Its main ability is, given two signals, to calculate a value whose magnitude indicates how similar the signals are. If one of the signals is delayed or shifted with respect to the other, repeated application of this matching technique can indicate how much one signal has to be shifted to match the other.

Variations of this technique were applied to short sampled extracts of recordings of early mechanical television pictures stored in computer. The aim was to find a method of accurately re-aligning a free-running sequence of frames for viewing and further processing.

Figure 2(a) shows a typical sequence of 10 frames digitized and stored in the computer memory: the first frame is on the right and all subsequent frames are to the left. The nature of the drift in frame position is quite evident. In the short space of time represented, the left and right edges of each frames have not drifted detectably, but, the images suffer from severe vertical drift in the position of line start and end (top and bottom), caused by wow and flutter in the recording medium of between 1 and 2%. The extremes of this variation would be equivalent to the difference between an image being perfectly level and one that is tilted by about 60°, corresponding to a change in the line start position from beginning to the end of a frame of about ⅔ line length. Figure 2(b) shows an estimate of the line-by-line positional error.

Also of importance is the frequency spectrum of this playback speed fluctuation. Figure 2(b) shows that fast fluctuations in speed are of much smaller amplitude than the slower frame-to-frame variations. The difficulty lies in obtaining correction methods able to cancel out *all* of these variations.

Method

Line matching. Figure 1 shows two waveforms, A and B. A is considered to be the reference and B is to be shifted to find the best match. As these waveforms represent two tv lines, the starts and ends of lines define limits. For this method to work, line B is assumed to be periodic, so that when shifted in one direction, the last sample in the line wraps around to become the first sample in the shifted line. Thus, the shifting appears to be a rotation. Waveform B is rotated a sample at a time. For each rotation, a matching score is calcu-

www.americanradiohistory.com

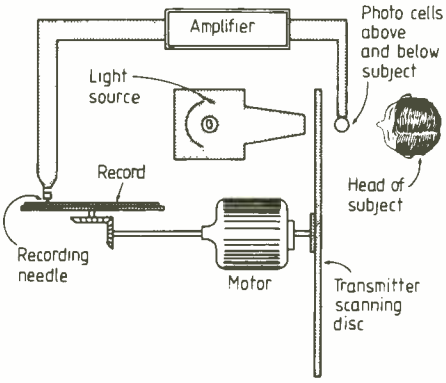


Fig. 4. Mechanical gearing of original apparatus provided steady sync.

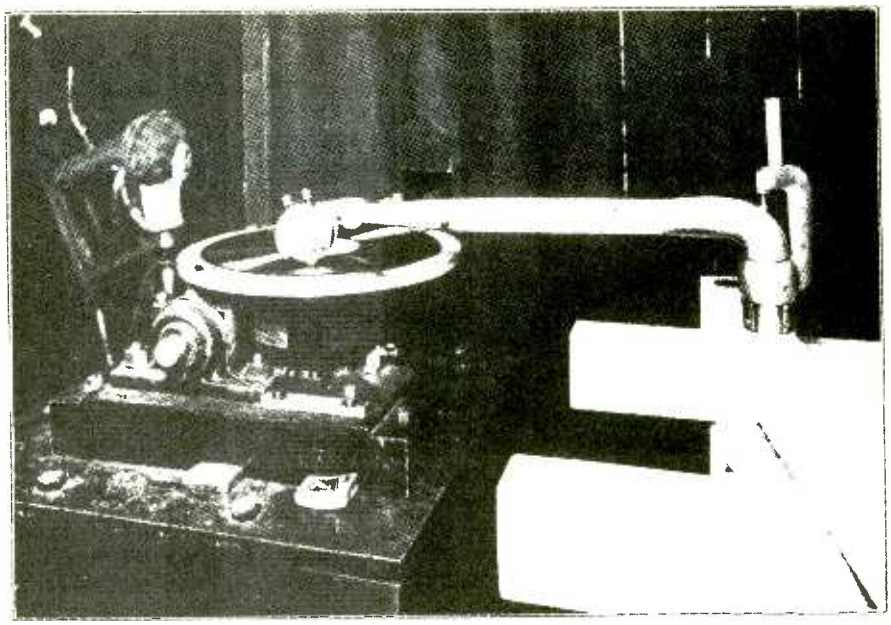


Fig. 5. System of Fig. 4 in use, recording the 'dummy head.'

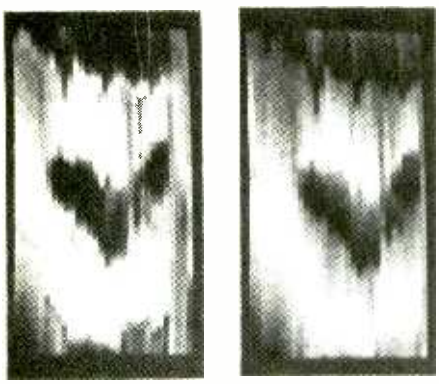


Fig. 6. Phase correction by all-pass filter.

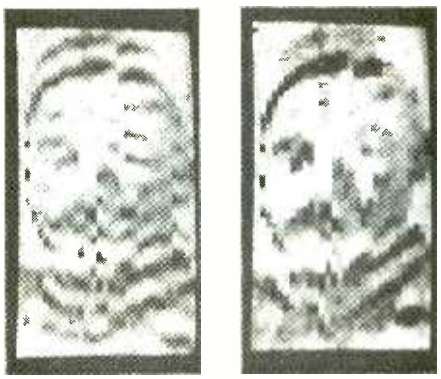


Fig. 7. Digital filtering was carried out within the computer.

Fig. 8. Further examples of digital filtering to reduce effect of head-cutter resonance.

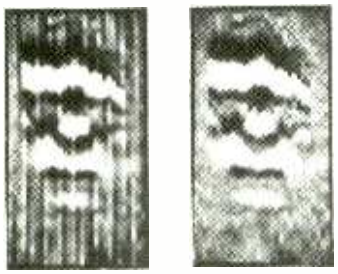


Fig. 9. Digital filter also used to reduce effect of low-frequency noise.

lated by multiplying each sample in the rotated line B by the corresponding sample in line A. The sum of these products is the matching score. The process is repeated by rotating line B and calculating another score for this new shift position, s. The equation below describes this sum of products.

$$CS(s) = \sum_{x=1}^{L} A(x).B(x-s)$$

where CS is the matching score, x is sample position from start of line, s is the current shift value in samples and L is the number of samples in the line.

The matching scores are stored in a list so that, at the end of one complete rotation of line B back to its starting position, the position in the list of the maximum score can be taken to be the number of samples by which B must be rotated to be 'lined-up' with A.

For each line in the current frame, the current line was matched against the corresponding line in the reference frame. The position of maximum score for the above equation was taken to be the value by which the current line had to be shifted to match best the line in the reference image. Initially the reference frame corresponded to the first frame in the sequence. After each line was corrected, the line in the reference frame was averaged with a fraction of the current line to take into account any scene change at the horizontal position of the line. The average was stored back in the reference frame.

The results of one-dimensional matching were somewhat mixed in success. For clear, stable and simple scenes, the results were excellent, leaving an extremely stable sequence of rectified frames with very low jitter in vertical position from one frame to the next. However, for fast-moving complex scenes, the performance was poor with unstable breaking up of the picture structure and consequent severe degradation in image quality.

Line-jitter removal. One of the recordings suffered from severe timebase jitter, causing large changes in the position of the start of the line on subsequent lines within a frame. In this case only it was considered worthwhile to use a different form of one-dimensional matching.

Instead of matching the current line in the frame being processed with the same line in the reference frame, the current line was matched against the previous line in the *same* frame. I have used this technique successfully with slow-scan television pictures received on the amateur bands[8]. Line-to-line jitter is removed in a fairly uncontrolled way at the expense of geometrical distortion of the picture. As it was considered important to maintain the picture geometry, this technique was not used on the other recordings.

The one recording which was processed using this technique suffered from static errors in the position of the start of each line in any frame. This was presumably caused by errors in the position of the holes in the scanning disc, causing some lines to start earlier or later than adjacent lines. Figure 11 shows a typical frame before and after correction of this fault.

Frame matching. The problem with the line matching technique was that it could only allow a small amount of lateral movement in the scene before instability degraded the picture quality. Because the matching algorithm was essentially one-dimensional in nature, it could not cope with

www.americanradiohistory.com

any sideways movement. The algorithm had no 'knowledge' of any structure in adjacent lines. To attack this problem, a variation on the original method was devised and tested with excellent results.

This new method was based on the fact that the scene content (not position) varied little from frame to frame. There was no abrupt scene changes. Each frame can be thought of as a two-dimensional brightness distribution where each point (x,y) has an associated brightness value B(x,y). Using one frame as a reference, the idea was to 'slide' the frame to be corrected horizontally (in x) and vertically (in y) until a best match was found. The equation for calculating the matching score at any shift value (s,t) was derived from the one-dimensional equation given earlier and is given below

$$CS(s,t)=\sum_{x=1}^{L}\sum_{y=1}^{M} A(x,y).B(x-s,y-t)$$

where A(x,y) is the brightness in the reference frame at point (x,y), B() is the brightness in the current frame being processed at the shifted (x,y), L,M are the max. no. of samples and lines in x and y respectively, and CS (s,t) is the score for a possible match at shift value (s,t).

The 'sliding' of the frames is similar to the cyclic shift used when matching lines (Fig. 1) but is extended to two dimensions. A cyclic shift of the current frame was performed for each shifted position (s,t), and all possible shifted positions of one frame with respect to the other was used to create a list of scores for matching.

Using the position of maximum score, the current frame was cyclically shifted from its original position in both x and y directions to match it with the reference frame. Each point of the current and reference frames was then averaged with a user-selected weighted value. The averaged result was stored to become a new reference frame for the next frame in the sequence, which served to accommodate increasing differences between the successive and reference frames.

The positional errors that had to be corrected were only in the vertical direction, however. During the time taken for a short sequence, the horizontal drift could be ignored as it was 1/30th of the amplitude of the vertical drift in this case. Correction only in the vertical direction was achieved simply by removing the calculated lateral (x) shift *after* the full two-dimensional matching and shifting had been applied and the reference frame updated with the weighted average. The averaging of the reference frame with a fraction of the current frame had to be done by using the current frame shifted in *both* horizontal and vertical directions to track lateral movement in the scene.

The effect of using two-dimensional processing but only correcting vertically was to allow horizontal motion without any loss of stability in the processed sequence of frames. It is indeed most fortunate that the line scanning direction of the early mechanical television experiments was vertical as most scene motion in natural objects is typically only from side to side.

Figures 2(a) to 2(e) show the performance of the basic two-dimensional correction method described in the previous subsection. Figure 2(a) is the original digitized sequence showing significant vertical rolling of the frames in the sequence. Figure 2(b) shows an estimate of the actual positional error in the vertical direction on a line by line basis. Figure 2(c) displays the actual calculated result of how much each line in each frame had to be shifted. Each line in a particular frame was shifted by the same amount so that the correction function (Fig. 2(c)) shows only a stepped approximation to the actual positional error. Figure 2(d) is the residual error after applying the offset of Fig. 2(c) and Fig. 2(e) is the corresponding corrected sequence of frames.

By comparing Figures 2(b) and 2(c), a closer approximation to the actual positional drift could be made by performing a linear interpolation between the vertical shift values of adjacent frames. The method was quite simple to implement and provided considerable improvement to frames distorted by sampling at a slightly incorrect sampling rate.

Figures 3(a) to 3(d) show the result of processing a sequence digitized at slightly too high a sampling rate. The result here is equivalent to a 0.7% increase in the desired sampling rate. Figure 3(b) shows the linearly-interpolated error derived from the vertical shift calculated using the matching equation: the error wraps around as the shift value has cyclic symmetry. Applying this interpolated set of values (Fig. 3(b)) to the original sequence gave rise to the processed sequence as shown in Fig. 3(d). Figure 3(c) shows the residual error. The most significant result from this example is the removal of the overall tilt from each frame.

A natural extension of the original line matching idea resulted in a stable and robust method of accurately re-aligning a sequence of tv frames with no further information than the scene being transmitted. The restriction of only applying vertical correction resulted in the

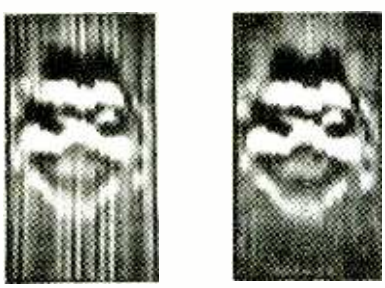


Fig. 10. Good example of removal of hum by digital filter.

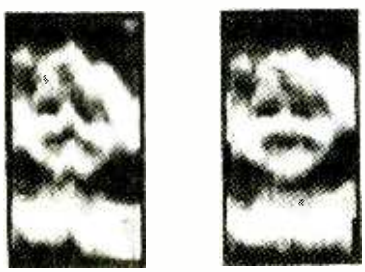


Fig. 11. Correction of variation of position of line starts within a frame.

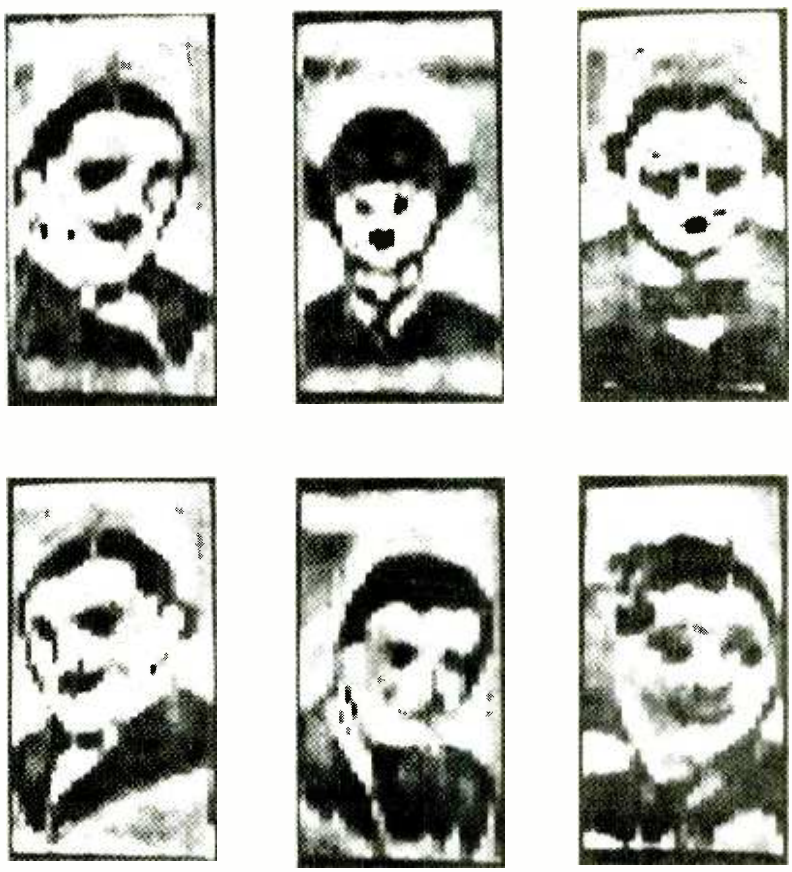


Fig. 12. Set of pictures produced by system from noisy and distorted taped recordings. Pictures are still crude, but are enormous improvement on untreated versions.

www.americanradiohistory.com

preservation of horizontal motion with no loss in stability. Further correction for speed variations proved to be a powerful method for removing the 'tilted' effect on certain frames. This required little computational overhead.

Although not able to remove fluctuations faster than the frame rate, the frame matching technique has proved to be a useful tool in assisting the analysis of these early mechanical recordings.

Image quality

The quality of recording on wax discs in the 1920's was adequate for voice or music reproduction although it was far from hi-fidelity. When used for recording Baird's 30 line television signal, wax discs proved themselves to be quite a poor recording medium. The recording apparatus was not capable of recording the very high or the very low frequencies in the signal, and yet the shape of the recorded waveform – much less important for voice or music recording – had to be free of distortion for accurate reproduction of the scene being televised.

The limitations of base-band (unmodulated) recording on wax discs resulted in various types of distortion of the television waveform. The most common types observed on the discs of the period are: phase distortion – poor low frequency response, giving rise to phase shifts; low-frequency noise – eg, main hum aggravated by reduced signal level at low frequencies; high-frequency instability generated by head cutter resonance; noise caused by disc surface granularity; and residual timebase errors, giving rise to ragged edges to each frame.

Image filtering

One-dimensional filtering. Most types of distortion present on these recordings can be reduced by one-dimensional digital filtering techniques. This means that the television signal is treated as if it were an audio signal: the relationship between lines and frames is not used in the processing.

Phase distortion can be reduced by processing the signal through an all-pass phase shifter. It is the author's experience that using a simple electronic circuit to perform this function relieves the computer from time-consuming processing and gives instant feedback on the correction being applied to the signal. Figure 6 shows the result of phase correction.

Head-cutter resonance is predominant on one particular recording. Although external pre-filtering can reduce the effect of the resonance, digital filtering within the computer was found to be much more flexible and was able to reduce the resonance without adversely affecting the resolution of the picture. Figures 7 and 8 show the reduction possible by digital filtering.

Low-frequency noise was more effectively reduced again by using digital filtering. In one of the recordings, mains hum was present at a high level after attempting to recover low frequency information in the signal. The reduction of interfering signals on early Baird recordings is demonstrated well on Figs 9 and 10.

The author

After graduating from Glasgow University, the author spent several years with EMI Central Research Laboratories before joining Logica as an image-processing consultant. With a strong grounding in television, he has worked on digital video and audio systems, automatic inspection methods and, more recently, on the image-processing system for a fingerprint identification system. In his spare time, he explores aspects of television techniques.

Although the waveform is by nature one-dimensional, the correlation between lines and frames can be used to suppress some types of irregularities in the signal. One particularly powerful technique involves processing the points in the scene exactly one frame apart, a process called temporal filtering.

Temporal filtering. One of the most effective processes on the frame- or line-matched sequence of frames was the temporal filter. Both surface noise and residual errors in the position of the lines were considerably reduced without affecting detail in the individual frames significantly.

The idea is that points having the same position along the same line on adjacent frames should be very close in their value of brightness. The filter creates a new point from the brightness values of the same point on three successive frames, chosen to be the middle value in brightness amongst the three. Using this median value allowed isolated errors to be corrected completely: line jitter, noise and to a lesser extent movement were suppressed without the blurring action of a spatial filter (i.e. one acting along or across lines). Reference 9 describes this technique applied to high resolution television.

Temporal filtering is both difficult and expensive to implement in high-resolution television because of the large amount of high speed memory required to store two (or more) frames. The memory and speed requirements for 30 line television however makes it very much simpler to demonstrate powerful image processing techniques such as this.

Software

A program for acquiring data, displaying the result, re-aligning and processing a digitized sequence of 30 line television was written in machine code for acquisition and re-transmission: the processing routines could have been written in any language. A decisive factor in using machine code for the matching algorithms was the vast number of calculations required to match-up and re-align the frames. For line matching, this included about one million multiply operations for a sequence of 32 frames. Matching up 32 frames took 150 seconds in Z80 machine code with the processor running at 4MHz. Performing the multiply operation in hardware reduced the execution time to 65 seconds for a 32 frame sequence.

The implementation of the two-dimensional frame matching took considerably longer to execute than that of the one-dimensional line matching, since frame matching needed a greater number of multiply and accumulate operations (30 times) plus higher precision in the score value for matching. Considering that an image or frame in this case had 960 samples, point-by-point multiplication and score accumulation gave the staggering figure of just under one million of these operations per frame. The software implementation took 3 minutes per frame – 96 minutes in total for a complete 32 frame sequence. Performing just the multiply operation in hardware reduced this execution time to 80 seconds per frame – 40 minutes per sequence. A similar routine in Basic was estimated to take about 75 hours per sequence, while a compiled PASCAL routine on the same machine took 17 hours per sequence.

The one-dimensional and temporal filtering all required between 2 and 10 seconds to process a 32 frame sequence of 960bytes per frame. For high-resolution processing with 1920 bytes per frame, fewer frames could be held in memory. Because the amount of data was similar in both the low and high-resolution sequences, the processing time for each was similar. Fourier analysis of the signals to determine which filter to use took a few minutes for each frame.

Acknowledgements

Thanks go to Doug Pitt of the Narrow Band TV Association, Ronald Gibb of Strathclyde University AV unit, Ray Herbert, Ben Clapp, H. Spencer, Len Firmin MBS, John Ive and Mike Hallett of the IBA and Tim Voore for assistance in researches into mechanical television.

References

'Phonovision'

1. Dinsdale, A. 'Television' 2nd edn. Television Press Ltd. 1928, pp 142-145.
2. Moseley & Barton Chapple 'Television – Today and Tomorrow' 2nd edn. Pitman & Sons 1931, pp 127-130.
3. Newnes 'Television and Short-Wave Handbook' 1st edn., 1934, pp 47-50.
4. *Television and Short-Wave World* June 1935, p308 and p363.
5. Patent no. 289104, 16-APR-29, J. L. Baird.
6. Matthewson, D.K. *Television*, May 1983, pp 361-2.

For details of crrelation techniques

7. Gonzalez & Wintz 'Digital Image Processing' Addison-Wesley, 1977, pp 67-69 and pp 383-386.

Further application of correlation:

8. *Rad-Com*. Letter on computer-controlled slow-scan TV. October 1982, pp872.

Details of temporal filtering:

9. Huang, T.S. 'Image Sequence Analysis' Springer-Verlag, 1981, Chapter 4.

Short extracts from one of the recordings can be heard along with interesting conmmentary on the following:

10. 'We seem to have lost the Picture,' BBC documentary l.p. REB 239 from the series '40 Years of TV,' 1977.

www.americanradiohistory.com

Assembly language programming

Parts of these lists were illegible when originally printed in Bob Coates' sixth tutorial in the September issue. We apologize for any inconvenience caused by the poor printing.

List 1. Assembly language for summing numbers on the Picotutor.

```
024     4F              CLRA                    CLEAR SUMMING REGISTER
025     AE52            LDX     #VALUE1         INIT. POINTER WITH 1ST 8 BIT VALUE ADD
027     FB      LOOP    ADD     0,X             ADD 8 BIT VALUE TO SUMMING REG.
028     5C              INCX                    INCREMENT POINTER
029     3A51            DEC     VALUES          DECREMENT COUNTER
02B     26FA            BNE     LOOP            BRANCH IF COUNTER NOT ZERO
02D     B750            STA     RESULT          STORE RESULT
02F     BC80            JMP     START           RETURN TO MONITOR
```

List 2. Summing numbers using the 6800.

```
1000    4F              CLRA
1001    CE1052          LDX     #VALUE1
1004    AB00    LOOP    ADDA    0,X
1006    08              INX
1007    7A1051          DEC     VALUES
100A    26F8            BNE     LOOP
100C    B71050          STA     RESULT
100F    7E7D97          JMP     START
```

List 3. Summing numbers using the 6809.

```
1000    4F              CLRA
1001    8E1052          LDX     #VALUE1
1004    AB00    LOOP    ADDA    0,X
1006    3001            LEAX    1,X
1008    7A1051          DEC     VALUES
100B    26F7            BNE     LOOP
100D    B71050          STA     RESULT
1010    7E7D97          JMP     START
```

List 4. Z80 number summing program.

```
2000    3A5120          LD      A,(VALUES)
2003    47              LD      B,A
2004    AF              XOR     A
2005    215220          LD      HL,VALUE1
2008    86      LOOP    ADD     A,(HL)
2009    23              INC     HL
200A    10FC            DJNZ    LOOP
200C    325020          LD      (RESULT),A
200F    C30000          JP      0
```

List 5. Multiplication program for the 6805.

```
024     3F62    MUL     CLR     PROD
026     3F63            CLR     PROD+1
028     AE08            LDX     #8
02A     3863    MUL1    LSL     PROD+1
02C     3962            ROL     PROD
02E     3861            LSL     MPLIER
030     240B            BCC     MUL2
032     B660            LDA     MCAND
034     BB63            ADD     PROD+1
036     B763            STA     PROD+1
038     4F              CLRA
039     B962            ADC     PROD
03B     B762            STA     PROD
03D     5A      MUL2    DECX
03E     26EA            BNE     MUL1
040     BC80            JMP     START
```

List 6. 15-by-7-bit division using the 6805.

```
024     AE08    DIV     LDX     #8              SET COUNTER
026     3861    DIV1    LSL     DDEND+1         SHIFT L QUOT./LS 8 BITS OF D/DEND
028     3960            ROL     DDEND           SHIFT L MS 8 BITS OF D/DEND
02A     3660            LDA     DDEND
02C     B162            CMP     DISOR           DO TRIAL SUBTRACTION
02E     2506            BCS     DIV2            BRANCH IF NOT SUCCESSFUL
030     B062            SUB     DISOR           SUBTRACT D/SOR FROM 8 MS BITS D/DEND
032     B760            STA     DDEND           STORE RESULT AS D/DEND
034     3C61            INC     DDEND+1         AND INC. QUOTIENT
036     5A      DIV2    DECX                    DEC. LOOP COUNTER
037     26ED            BNE DIV1                BRANCH IF NOT FINISHED
039     BC80            JMP     START           FINISH
```

List 7. Simulation of the 6800 DAA instruction included in the Picotutor.

```
                        * DAA - THIS ROUTINE SIMULATES THE DAA INSTRUCTION OF THE
                        *       6800 ETC.   IT SHOULD BE CALLED AFTER AN ADD OR AI
                        *       INSTRUCTION AS....   JSR DAA.
                        *       UPON EXIT, A IS BCD CORRECTED AND C IS SET FOR
                        *       MULTIPRECISION BCD ADD.
                        *
386     B71E    DAA     STA     TEMPA           SAVE INPUT VALUE
388     BF1F            STX     TEMPX
                        *
                        * CALCULATE CORRECTION FACTOR
                        *
38A     5F              CLRX                    BUILD CORRECTION IN X
38B     101D            BSET    0,BITSTR        SET CARRY STORE
                        *
38D     2506            BCS     DAAHG
38F     111D            BCLR    0,BITSTR        BUT CLEAR CARRY STORE IF CARRY ISN'T SET
391     A199            CMP     #H'99'
393     2302            BLS     DAALOW          INPUT <=H'99'
395     AE60            LDX     #H'60'            HIGH NIBBLE NEEDS CORRECTION
                        *
397     2906    DAALOW  BHCS    DAAL6
399     A40F            AND     #H'F'
39B     A109            CMP     #9
39D     2304            BLS     DAADNE          NO LOW NIBBLE CORRECTION
39F     9F      DAAL6   TXA
3A0     AB06            ADD     #H'6'             LOW NIBBLE CORRECTION
3A2     97              TAX                     TOTAL ADJUST BACK TO X
                        *
                        * CORRECT ACCUMULATOR NOW
                        *
```

continued over

www.americanradiohistory.com

List 7. *(continued).*

```
3A3   9F        DAADNE   TXA              CORRECTION GOES INTO A
3A4   BB1E               ADD    TEMPA     AND IS ADDED TO ORIGINAL VALUE
3A6   BE1F               LDX    TEMPX
3A8   2504               BCS    DAA2      BRANCH OUT IF CARRY ALREADY SET
3AA   011D01             BRCLR  0,BITSTR,DAA2 OR IF IT WAS CLEAR ON ENTRY
3AD   99                 SEC              BUT SET CARRY IF IT WAS ON ENTRY
3AE   81        DAA2     RTS
```

List 8. Adding two numbers using the simulator of List 7.

```
024   A699      LDA    #$99
026   A849      ADD    #$49
028   83        SWI
029   BDB3      JSR    DAA
02B   83        SWI
```

List 9. Converting decimal 2748 to binary form using Picotutor.

```
024   A627      LDA    #$27
026   B71A      STA    POINT
028   A648      LDA    #$48
02A   B71B      STA    POINT+1
02C   AE60      LDX    #$60
02E   BDB9      JSR    BCDBIN
030   BC80      JMP    START
```

List 10. Assembly language for Picotutor subroutine BCDBIN.

```
                841 * BCDBIN - CONVERTS A 4 DIGIT PACKED BCD NUMBER IN
                842 *          POINT TO 14 BIT BINARY, AND PLACES
                843 *          RESULYT IN 0,X/1,X.  BCD NUMBER
                844 *          UNALTERED. SETS CARRY IF A NON-DECIMAL
                845 *          DIGIT ENTERED.
                846 *
404   7F        431  847 BCDBIN CLR    0,X       CLEAR RESULT REGISTERS
405   6F01      432  848        CLR    1,X
407   131D      433  849        BCLR   1,BITSTR CLEAR OVERFLOW FLAG
409   B61A      434  850        LDA    POINT    PUT 1000'S DIGIT IN POINTS
40B   44        435  851        LSRA
40C   44        436  852        LSRA
40D   44        437  853        LSRA
40E   44        438  854        LSRA
40F   B71C      439  855        STA    POINTS
411   AD47      440  856        BSR    BCDCHK   CHECK DIGIT IS <=9
413   270A      441  857        BEQ    BCB2     BRANCH IF DIGIT = 0
                     858 *
415   A603      442  859 BCB1   LDA    #3       ADD H'300' TO RESULT
417   FB        443  860        ADD    0,X
418   F7        444  861        STA    0,X
419   A6E8      445  862        LDA    #H'E8'     ADD H'E8' TO RESULT
41B   AD32      446  863        BSR    BCDADD   (TOTAL ADD=H'3E8', 1000 DEC)
41D   26F6      447  864        BNE    BCB1     BRANCH IF 1000'S NOT ZERO
                     865 *
                     866 *
41F   B61A      448  867 BCB2   LDA    POINT    PUT 100'S DIGIT IN POINTS
421   A40F      449  868        AND    #H'F'
423   B71C      450  869        STA    POINTS
425   AD33      451  870        BSR    BCDCHK
427   2706      452  871        BEQ    BCB4     BRANCH IF DIGIT = 0
                     872 *
429   A664      453  873 BCB3   LDA    #H'64'     ADD H'64' (100) TO RESULT
42B   AD22      454  874        BSR    BCDADD
42D   26FA      455  875        BNE    BCB3
                     876 *
                     877 *
42F   B61B      456  878 BCB4   LDA    POINT+1  PUT 10'S DIGIT IN POINTS
431   44        457  879        LSRA
432   44        458  880        LSRA
433   44        459  881        LSRA
434   44        460  882        LSRA
435   B71C      461  883        STA    POINTS
437   AD21      462  884        BSR    BCDCHK
439   2706      463  885        BEQ    BCB6
                     886 *
43B   A60A      464  887 BCB5   LDA    #H'A'      ADD H'A' (10) TO RESULT
43D   AD10      465  888        BSR    BCDADD
43F   26FA      466  889        BNE    BCB5
                     890 *
                     891 *
441   B61B      467  892 BCB6   LDA    POINT+1  ADD 1'S TO RESULT
443   A40F      468  893        AND    #H'F'
445   AD13      469  894        BSR    BCDCHK
447   AD06      470  895        BSR    BCDADD
                     896 *
                     897 *
449   98        471  898        CLC
44A   031D01    472  899        BRCLR  1,BITSTR,BCB7 BRANCH IF NO ERROR
44D   99        473  900        SEC              SET CARRY AS NON-DECIMAL NO.
44E   81        474  901 BCB7   RTS              RETURN, CONVERSION COMPLETE
                     902 *
                     903 *
                     904 *
44F   EB01      475  905 BCDADD ADD    1,X      ADD NUMBER IN A TO RESULT
451   E701      476  906        STA    1,X
453   A600      477  907        LDA    #0
455   F9        478  908        ADC    0,X      PASS ON CARRY
456   F7        479  909        STA    0,X
457   3A1C      480  910        DEC    POINTS   DECREMENT THE DECIMAL DIGIT
459   81        481  911        RTS
                     912 *
                     913 *
                     914 *
45A   A109      482  915 BCDCHK CMPA   #9       SET ERROR FLAG IF DIGIT >9
45C   2302      483  916        BLS    BCDCH1
45E   121D      484  917        BSET   1,BITSTR SET FLAG
460   4D        485  918 BCDCH1 TSTA
461   81        486  919        RTS
```


www.americanradiohistory.com

Forth language

Complementing his description of a 6809-based microcomputer, Brian Woodroffe details the language used – Forth – and why he chose it, in this second series.

by B. Woodroffe

Forth is a language well suited to modern microprocessors and is widely used in such diverse applications as word processing, data-base management, instrument and process control, video games and data acquisition. In a kernel of less than 10Kbyte the following features are provided

– An interactive system.
– A high-level compiler with all standard control features.
– Fast execution, comparable with machine code because of the compiler.
– The language system is largely processor independent; only around 20% of the code written in assembly language need be changed to suit the computer.
– Virtual memory and application-oriented program modules.

Further, the system may be readily extended to suit new applications because the compiler can be modified by the user and new data structures introduced. These features are achieved by defining a virtual machine which is easily simulated by any target machine. Using 'threaded code', transferring control in the host from one virtual machine instruction to the next is quick and easy. Instructions of the virtual machine are used to build the monitor and compiler. Using the monitor the user may examine the effect of a series of Forth instructions and using the compiler this series may be added to the instruction set for future use.

Background

Forth is a computer language for fourth generation computers[1]. The language would have been called Fourth but six letters would not fit in the IBM1130 job-control language that its inventor, C. H. Moore, was then working with. Today Moore's company Forth Inc. is foremost in marketing FORTH for many different applications, besides the field of astronomy where it first found favour[2]. Other companies such as Miller Microcomputer Services and Laboratory Microsystems sell their own versions of Forth but the prime mover of Forth in the home-computer/hobby field is the Forth Interest Group* (FIG). They have made versions of Forth available for many computers including the PDP-11 and for 8080/Z80, 6800, 8086/8088 and 6502 processors. There are many versions of Forth and while all are similar no two are necessarily identical. For example, Poly Forth, FIG Forth and Forth 79 are all Forth but they are not the same. They differ primarily because of differences in the processor on which they run (16 or 8 bit memory, port or memory mapped i/o, etc.). FIG Forth will be used in all following examples.

*Forth Interest Group, PO Box 1105, San Carlos, CA94070, USA.

Forth is a collation of different sofware concepts forming a coherent whole. As an operating system, it is not as powerful as most but it takes care of all terminal and disc input and output. Small assembly-language routines must be supplied by the user to interface his hardware to the relevant system calls. It is also possible that memory-allocation changes may also have to be made. Most of Forth is written in Forth. It may seem strange that a language may be defined in terms of itself but one would use English words to explain the English language. Defining the language in this way means that programs may be transferred between different computers and implementations. There is a base instruction set which must be written in the machine code of the host computer. This is the only machine code required and the process is known as simulating a virtual Forth machine.

Most computer languages are programs which, recognizing statements in a source language, convert them into a target language. Usually the source language is text readable by humans in ASCII form and output is machine code of the computer. This is not always the case: cross compiling results in the target code being different from the host computer machine code. More exceptionally there are cases where the machine code can only be executed by a hypothetical computer, an example being O-code for the language BCPL[3] and P-Code for certain implementations of Pascal[4]. This is also the case for Forth and the virtual-machine execution mechanism will be explained first.

Threaded code

Explanation is simplified by visualizing a machine-code program for the processor concerned as a succession of subroutine calls. These calls transfer program control to each subroutine in turn. A stack, i.e., last-in-first-out list, would be the mechanism by which each subroutine returns control to the correct point in the main program. Knowing that the main program is solely a succession of calls it is now possible to reduce the main program to a list of subroutine addresses by removing the subroutine op-code, and to have a special program known as an address interpreter to transfer control down the main program address list. This is called threaded code, for the main program is the thread into and out of which the address interpreter threads control[5], List 1.

List 1. Comparisons of hard code and direct threaded code.

Normal code	Threaded code	
	Address interpreter	Thread
call A	1: ip+1 –> ip	A
call B	call [ip]	B
call C	jmp 1	C

In List 1, letters A, B and C denote machine-code subroutines, ip is the threaded-code instruction pointer and parentheses indicate one level of indirection. Threaded code trades the cost of the code for each call saved for address interpreter speed. In a long program the code cost of the address interpreter will be negligible. Further savings can be made by replacing the subroutine return statement by a jump to the address interpreter and changing the address interpreter as shown below. This releases the stack pointer used for subroutine calls and returns. It is important that the instruction pointer can be speedily accessed, for example by keeping it in a processor register, so as not to slow down the address interpreter by causing unnecessary memory activity.

If the lists are considered to be the actions of a virtual machine then a software routine NEXT represents the hardware execution fetch of the virtual machine. In a threaded-code computer the time of interpreting these lists is dominated by the time of the NEXT operation so it is best to run threaded code on a computer that handles NEXT efficiently or to use microcode.

```
Code routine including return
A:  xxx
    jmp NEXT

New address interpreter
NEXT:  ip+1 –> ip
       jmp [ip]
```

Indirect threaded code

The next improvement is to allow called routines to be not just pure machine code but also address lists. This is done by having a special routine that knows that the following data in the list are not code but addresses that must again be interpreted. Further, the routine must suspend interpretation of the main program while interpreting this new list of addresses. Return of control to the suspended list is done using a stack to save and restore the instruction pointer which is similar to the machine-code subroutine call/return operation. There must be an equivalent code routine to return control to the main list.

```
Normal code routine
A:  machine code
    . . .
    jmp NEXT
```


www.americanradiohistory.com

```
Threaded routine
P: sp-1 -> sp
   ip     ->[sp]  (push current ip)
   #L-1 -> ip     (start interpreting new
                   list)
   jmp NEXT
L: A               (code routine)
   B
   C

Return routine
[sp] -> ip         (pop ip)
sp+1 -> sp
jmp NEXT
```

As most routines are likely to be lists and not machine code this stacking method, similar to subroutine calling, will take a lot of code area. Considerable space would be saved if there was just one copy of this routine. The address interpreter would normally jump to this routine but it would also have to execute code routines. This is done by making the first element of each list a pointer to code rather than the code itself. In the case of lists the pointer points to the stacking operator but with code routines it points to the next code address.

```
New address interpreter
NEXT: ip+1 -> ip
      [ip] -> w
      jmp [w]

Stacking operation
DOCOL: sp-1 -> sp
       ip     -> [sp]
       w+1 -> ip
       jmp NEXT

Destacking operation
SEMIS: [sp]   ->ip
       sp+1 -> sp
       jmp NEXT

Code routine
A: $+1   (point to next location)
   xxx
   . . .
   jmp NEXT

List routine
DOCOL
P
Q
SEMIS
```

This is the equivalent of machine-code subroutine call and return instructions. In Forth, the stacking and destacking operations are called DOCOL and SEMIS respectively. At the beginning of each address list, the extra address introduces a level of indirection – this is indirect threaded code[6]. In Forth the lists are divided into two parts, one being the code field which points to the address and the other known as the parameter field where the code is. These two parts and dictionary data, to be described, form a WORD. Code pointed to by the code field determines how the parameter field is interpreted. In the case of code words, the code field points to the parameter field. When the code field points to DOCOL, the parameter field is to be interpreted in a similar way to a subroutine. It is possible for the code field to point to some other routine which may make different use of the parameter field. Two examples of this in Forth are DOCON and DOVAR. The former treats the value in the parameter field as a constant and pushes it onto the data stack, to be described, whereas DOVAR pushes the address of the parameter field which is used as the storage location for that variable. To enable these routines to access the parameter field a third register, known as 'w', is required.

The address interpreter for indirect threaded code is more complicated than that for direct threaded code and so it is even more important to choose a processor with a suitable instruction set. Surprisingly for direct threaded code, NEXT can normally be coded using the processor subroutine-return op-code provided that the processor uses a stack that may be placed anywhere in memory. As the stack pointer is pointing to the thread, the processor must not receive interrupts for the status cannot be saved without destroying the thread. NEXT for indirect code is more complicated as it involves an extra level of indirection.

Choosing a processor, stacks and language-control structures are subjects of the next Forth language article.

An i.c. in the Forth computer switch-mode power supply on page 61 of the July issue was incorrectly designated the MC3045. The correct designation is MC3405.

References

1. C. Moore, *Forth dimensions*, vol. 1, no. 6, FIG
2. C. Moore, *Astronomical Astrophysics Supplement*, 1974, vol. 15, pp.497-511
3. M. Richards, The portability of the BCPL compiler, *Software Experience and Practice*, 1976, vol. 1, pp.135-146
4. D. Barron, Pascal, the language and its implications, Wiley, 1981
5. J. Bell, *Communications of the ACM*, vol. 16, no. 6, pp.370-372
6. B. Dewar, *Communications of the ACM*, vol. 18, no. 6, pp.330-331

Glossary

Machine code. The representation, usually in hexadecimal, of the instruction and data encoding that is understood by the computer.

Assembly code. A human readable form of machine code. There is a one-to-one correspondence between assembly code and machine code.

Instruction fetch. A computer works by successively fetching and executing instructions. The instruction fetch is made from the location pointed to by the program counter. The program counter is incremented one instruction at a time unless a jump (branch etc) occurs.

Virtual machine. At any level of analysis the computer will have a repertoire of instructions that it can execute. This is normally the machine/assembly level instructions. However by running a program on this machine it can be made to look as though it has a different instruction set. It is possible to time share the computer between two or more users so that they both think they have a separate computer. These techniques are known as creating a virtual machine.

Op-code. Each different instruction is encoded into a unique symbol (usually binary, known as an op-code.

Host computer. The computer on which the program is currently executing.

Target computer. The computer on which the program being developed will execute.

Cross compilation. A cross compiler runs on one machine and produces output for another. Host and target machines have either different op-code encodings or instruction sets, or both.

Compiler. A program recognizes that the input language agrees with a defined grammar. If it agrees it will usually produce an output in some other defined language, or error messages as to why the input is not in the source language. Normally, input is English-like (e.g. Forth/Pascal) and output is machine code.

Microcode. Microcode is a mechanism used to build computers to understand machine-code instructions. Within a microcoded computer there is another computer with its own microcode instruction set. By writing new microcode, the assembly-level machine can be made to have new instructions.

Kernel. A central program on whose resources all application program rely and interface to.

Operating system. A computer program which manages the computer's resources. (It will take care of all input-output etc, so that the application programmer need not worry about how to get characters to and from a terminal, etc)

Software driver. A small program specific to each input/output device that is included in the operating system.

Terminal. Visual-display unit and keyboard, teletype.

Indirection. An addressing mechanism. An instruction requires data to act upon – the instruction gives details of how to find that data. Normally it will give the address of the data, but in the cases of indirect addressing it will give the address at which the address of the data may be found. That is one level of indirection. Up to three levels, ie the address which contains the address which contains the address which contains the address which contains the data, are common.

Call. A subroutine call is a mechanism whereby machine-code execution is temporarily suspended while the subroutine is executed. Execution will restart at the instruction after the call when the subroutine finishes. The restart address (return address) is often kept on a stack.

Code field. A part of a Forth Word definition. The contents of the code field always point to machine code of the target machine.

Machine. Computer, (state machine).

Monitor. A program that monitors user requests as typed in at the terminal. Usually gives message (<OK>) when the command has successfully executed. Monitor is also the name given to a technique used in real-time programming, developed by C.A.R. Hoare et al.

Virtual Forth machine. The assembly-language programmer creates a virtual machine that executes lowest-level Forth instructions.

Virtual-machine execution mechanism. The means by which the assembly-language programmer makes the virtual Forth machine transfer control from one Forth instruction to the next.

www.americanradiohistory.com

Nanocomp to teletypewriter interface

Hard copy of Nanocomp programs can be obtained cheaply using a teletypewriter and this simple interface with its machine-code driving program. Software presented is for the 6502 Nanocomp.

by P. C. Barton

A surplus teletyprewriter provides a very economical means of obtaining good quality hard copy of Nanocomp programs, the only drawbacks being the unit's size and its relatively low speed and somewhat noisy operation. Two points on the Nanocomp connector, p.i.a. line PB_7 and 0V, feed the input of this simple interface and its output consists of two connections which drive the teletypewriter selector magnet. Hard and software described was designed around the Creed 7E teletypewriter which has a 230V a.c. motor and is probably the most common on the second-hand market.

Hardware

The complete circuit consists of the teletypewriter-drive interface, Fig. 1, the power supply. Construction is straightforward. Two rails are provided by the p.s.u., between 80 and 100V to drive the teletypewriter selector magnet and 5V supplying the 7400 i.c. An alternative 5V source might be the Nanocomp's own p.s.u. In the original power supply I used a 20VA transformer built from a kit (RS207-728) with secondary windings consisting of 845 turns of 36 s.w.g. wire, centre-tapped, to provide 65-0-65V and 46 turns of 34 s.w.g. wire for the 5V secondary winding.

Software

Designed for the 6502 Nanocomp, the 397-byte program shown in List 1 resides in the top ram area starting at address 1264_{16}. When run the program displays an S to prompt entry of the printing start address and when that is entered an F prompt appears to indicate that the finishing address is to be entered. When the finishing address is entered the teletypewriter prints all memory contents between the specified addresses. Prompt functions make use of the Nanocomp monitor BADDR subroutine at 7C5B.

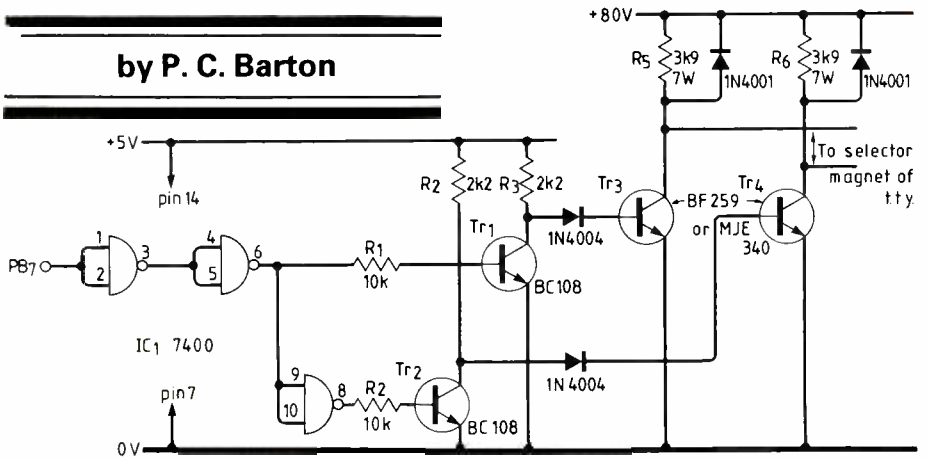
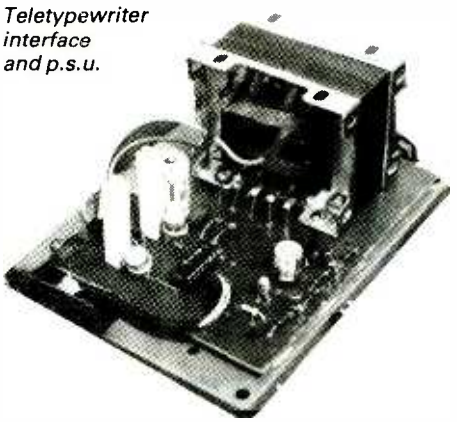


Fig 1. Nanocomp-to-teletypewriter interface in which high-voltage output transistors are driven by a phase-splitting circuit consisting of a 7400 i.c. and buffers.

One inconvenience with using teletypewriters is that when letters have been printed a figures code has to be sent before figures can be printed and likewise a letters signal has to be sent before letters can be printed. Unfortunately, hexadecimal notation consists of approximately ⅔ numbers



Teletypewriter interface and p.s.u.

Address	Function
0001	position counter
0002	data store (one hex. digit)
0003	figures/letters flag
0004, 0005	start address
0006, 0007	finish address
0008	drop memory
0009	temporary store (4 m.s.b. data byte)
000A	temporary store (4 l.s.b. data byte)
000B	byte flag
000C	byte count (CR, LF, spaces)
000D, 000E	look-up table temporary store
13C9	start of look-up table
Address	**Subroutine**
1353	letters/figures
1382	byte separation & storage
13AA	transmit

***List 2.** Memory locations used by the 397-byte interface program starting at location 1264, and subroutines.*

1260	00	00	00	00	86	3D	97	7F	BD	7C	B5	DF	04	86	69	97	1330	13	82	BD	13	53	96	02	97	08	BD	13	C9	BD	13	AA	96
1270	7F	BD	7C	B5	DF	06	4F	97	0C	97	03	97	0B	86	FF	97	1340	01	4C	97	01	DE	04	08	DF	04	9C	06	27	03	7E	12	81
1280	01	D6	01	C1	22	22	25	C1	04	22	02	20	30	86	0C	4C	1350	3F	01	01	96	02	81	09	22	08	86	00	91	03	27	15	20
1290	97	0C	01	01	01	81	02	22	02	20	22	86	13	97	08	BD	1360	1E	86	00	91	03	27	18	86	7F	97	08	BD	13	AA	86	00
12A0	13	AA	4F	97	0C	4C	9B	01	97	01	20	11	86	0B	97	08	1370	97	03	20	0B	86	6F	97	08	BD	13	AA	86	01	97	03	01
12B0	BD	13	AA	86	23	97	08	BD	13	AA	4F	97	01	01	96	01	1380	39	01	DE	04	A6	00	84	0F	97	0A	A6	00	44	44	44	44
12C0	81	05	22	5A	96	04	44	44	44	44	97	02	BD	13	53	96	1390	97	09	D6	0B	C1	00	26	0A	96	09	97	02	86	01	97	0B
12D0	02	97	08	BD	13	C9	BD	13	AA	96	04	84	0F	97	02	BD	13A0	20	07	96	0A	97	02	5F	D7	0B	39	96	08	7F	40	03	C6
12E0	13	53	96	02	97	08	BD	13	C9	BD	13	AA	96	05	44	44	13B0	80	F7	40	01	C6	04	F7	40	03	C6	07	B7	40	01	CE	07
12F0	44	44	97	02	BD	13	53	96	02	97	08	BD	13	C9	BD	13	13C0	FF	09	26	FD	49	5A	26	F3	39	86	13	B7	13	DE	7F	13
1300	AA	96	05	84	0F	97	02	BD	13	53	96	02	97	08	BD	13	13D0	DF	96	08	B7	13	DF	FE	13	DE	A6	E0	97	08	39	13	00
1310	C9	BD	13	AA	86	13	97	08	BD	13	AA	86	05	97	01	BD	13E0	37	77	67	43	2B	07	57	73	33	0F	63	4F	3B	4B	43	5B
1320	13	82	BD	13	53	96	02	97	08	BD	13	C9	BD	13	AA	BD	13F0	3F	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

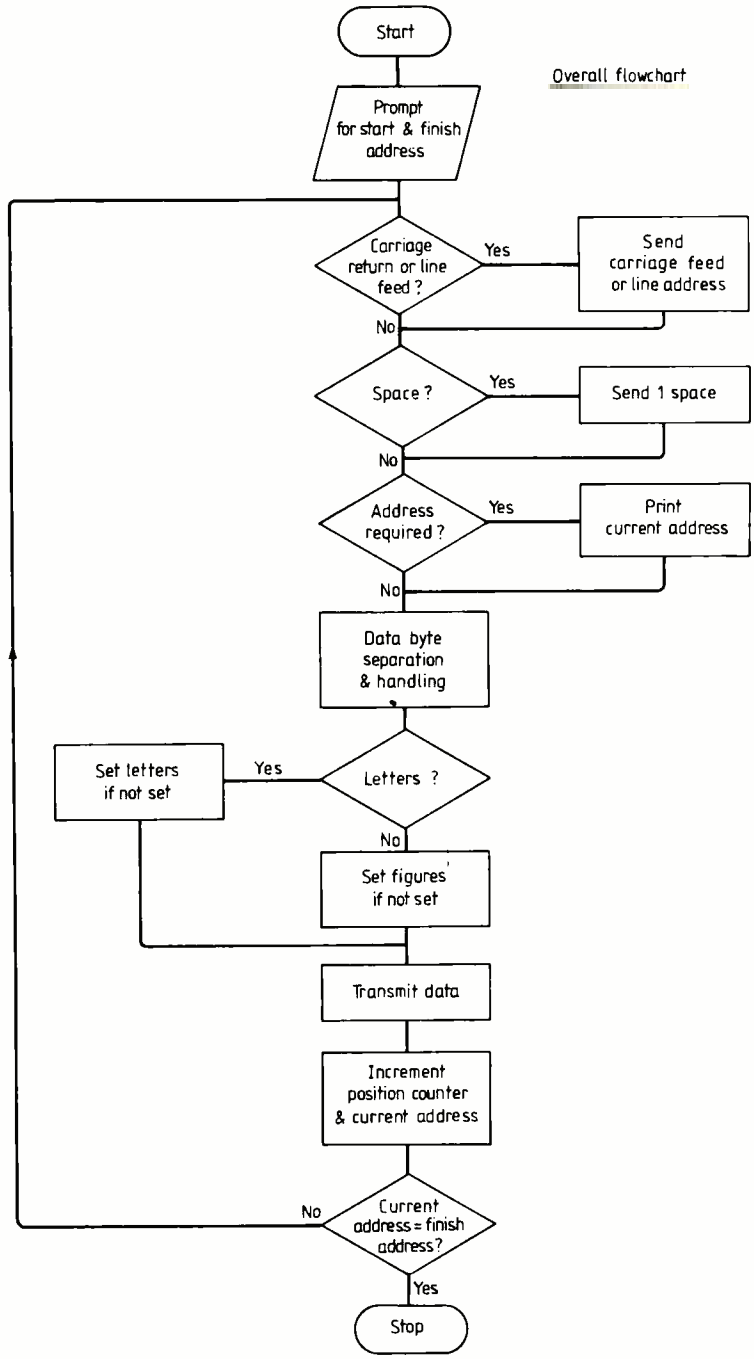
***List 1.** Machine code for driving a teletypewriter using the 6502 Nanocomp see List 2 for details.*

www.americanradiohistory.com

and ⅓ alphabetical figures and the extra code characters required to change between the two slows down printing.

Carriage returns, CR, and line feeds, LF, are sent as needed and if the position counter is below six the address is also printed, see flow diagram. If the next data byte is a letter and the teletypewriter is set for figures, the appropriate code is sent to convert to letters, and vice versa. Using a look-up table, data are converted to teletypewriter code and sent through 'drop' memory at address location 0008 to the teletypewriter interface using the transmit subroutine at 13AA. When the required section of memory has been printed, the program is terminated by a software interrupt instruction, SWI, which returns control to the monitor. List 2 is a memory map for those of you who want to make further use of the subroutines. If the teletypewriter races or prints rubbish try interchanging the selector magnet connections.

Bob Coates described the 6502 Nanocomp microprocessor trainer in the January 1981 issue, pp.32-36, and the 6809 version in July 1981, pp.33-37. An eprom programmer for both versions was described in the January 1982 issue, pp.30-33, and interfaces for expansion in November of the same year, pp. 32-34. A set of photocopies of these articles can be obtained by sending £2.55 and a large s.a.e. to Wireless World Trainer, Room L303, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.



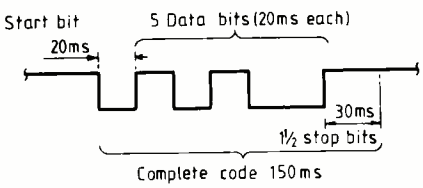
Interface details

The teletypewriter selector magnet can be in one of two states corresponding to logical one or zero. This magnet converts electrical impulses provided by two high-voltage output transistors, see Fig. 1, into mechanical movement which prints the appropriate character. Sections A and B of the i.c form a phase splitter which drives the output transistors in opposition, causing the magnet to shift from one state to another.

Teletypewriters use the CCITT No. 2 International 5 Unit Teleprinter Code in which five units, or bits, form the character to be printed. In addition, one start bit and one and a half stop bits are used, giving seven and a half bits in all. Each bit is 20ms long so each character including start and stop bits is 150ms long, fig. 2. The complete code is shown in Fig. 3.

Fig. 2. In teletypewriter code, five bits specify the character to be printed, one bit is the start bit and one and a half bits form the stop code.

Fig. 3. International 5-unit teleprinter code. A letter code changes from figures to letters and vice versa for a figure code. Channel numbers are the equivalent of bit numbers and a punched hole represents a logical one.



THE INTERNATIONAL 5-UNIT TELEPRINTER CODE

LETTERS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z						
CHANNEL 1	●	●		●	●	●				●	●						●		●		●		●	●	●	●			●	●		
—"— 2	●		●				●		●	●	●	●				●	●	●			●	●	●					●	●	●		
FEED HOLES	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CHANNEL 3			●			●		●	●		●		●	●		●	●		●		●	●		●	●				●		●	
—"— 4		●	●	●		●	●			●	●		●	●	●			●				●		●			●		●	●		
—"— 5		●					●	●				●	●		●	●	●			●		●	●	●	●	●			●	●		
FIGURES	—	?	: WHO ARE YOU		3	OPTIONALS			8 BELL		(	)	.	,	9	0	1	4	'	5	7	=	2	/ CARRIAGE RETURN	6	+	LINE FEED	LETTERS	FIGURES		SPACE	ALL SPACE
COMBINATION No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

TRACK: 5, 4, F, 3, 2, 1

www.americanradiohistory.com

LETTERS

RECHARGEABLE H.T. BATTERY

May I comment on Mr Pash's letter concerning the Milnes rechargeable h.t. battery.

This was first produced in the late 1920s by the Milnes Radio Company of Yorkshire. The cells were nickel-cadmium type with alkaline potassium hydroxide electrolyte, producing a potential when charged of about 1¼V. All the cells were connected in series to give 120V for normal operation; but could be connected in a series-parallel arrangement with a built-in switch, so that the unit could be recharged from a normal 6V battery charger.

Unlike lead-acid accumulators, nickel-cadmium cells can survive to a ripe old age and it is very interesting to learn that the unit Mr Pash has found bears this out. The makers at the time claimed that they were 'virtually indestructible'.

D. P. Leggatt
Engineering
Information Department
BBC

'CURRENT DUMPERS'

To quote Michael McLoughlan (September, p.39), "it is therefore appropriate to call the output transistors in Fig. 1 the 'current dumpers'."

The Concise Oxford Dictionary, for example, explains that "to dump" means to deposit (rubbish, etc.), to abandon, to export at a low price goods unsaleable in the country of origin. I am unable to see the claimed appropriateness of the term in the context of the article.

Could this be one of the causes of the confusion which, as Mr McLoughlan mentions, has surrounded this subject?

M. G. Scroggie
Bexhill
Sussex

DESIGN COMPETITION

I was interested to read Mr Wattson's plea (September Letters) for a 'discriminating' hearing aid, as I did some research relevant to the problem some years ago.

I wanted to find out why two ears give a good idea of the direction of sounds, and therefore the ability to discriminate, when two microphones do not. The answer is simply that the ear lobes (and to some extent the sound 'shadow' cast by the head) modify the sound in a way that the brain can interpret as direction. If one 'blanks off' the cars with one's hands, then the ability to judge direction deteriorates and, for instance, conversation in a room sounds cavernous.

I experimented with ears modelled out of Plasticene and later papier maché, with small microphone inserts set in them. This gave quite spectacular results when listening over headphones – sounds being locatable through 360 degrees and also above the 'head'. I understand that this was first discovered by Bell Labs. in the 1930s, and is currently being re-discovered under the name of 'Holophony'.

A hearing aid shaped like a head would take a little social adjustment (which is why I did not pursue my recording idea!), but if a microphone could be placed inside the ear 'on top' of the earpiece, thus using the effect of the ear lobes, this would work. However, the problem of avoiding feedback would be formidable. Another possibility would be to put the microphone in one ear and the earpiece in the other. Information would be 'back to front' but if the aid was always worn I expect one would soon get used to it. The other possibility is that enough directional information could be generated electronically from a small array of microphones.

Developing the idea may be a good candidate for an undergraduate project?

Richard Buswell
Buswell Machine Electronics
Skelmersdale
Lancashire

★ ★ ★

Being deaf myself, I applaud Mr Wattson's plea for help with hearing, but I am not clear that he has properly stated the problem.

Inability to cut out or subdue unwanted sounds is a common complaint, not necessarily linked to deafness. ITV, when recently asked to cut down the background music and effects to their productions, replied that the output was in fact well-balanced, it was the listener who was at fault.

But the inability to hear clearly when wearing a hearing aid in conditions of high ambient noise is another problem.

Cosmetically tucked behind an ear it has the inherent disadvantage of responding mainly to sounds behind the wearer, both volume and frequency in front being much reduced.

Truly did Dunlop, in the Textbook of Medical Treatment, say "in older people, the old-fashioned ear trumpet may well be found more effective".

The problem is really serious. For instance, a conversation in a bar at opening time becomes more and more difficult as the arrival of more people increases the ambient noise, and after a time can become quite impossible. This also goes for cafés, wedding receptions; in fact, anything which generates ambient noise.

I think a solution could lie in the use of the 'T' switch, which enables direct pickup by induction without the mike, from a telephone coil, or a radiating cable in suitably equipped theatres.

If your young men could devise a modern equivalent of the ear trumpet – something that picks up sound from a forward direction, amplifies it and feeds it to a loop which could be 'heard' on the 'T' setting it would be a boon to everyone with a behind-the-ear aid.

G. Barnes
Market Harborough
Leicestershire

HERETICS GUIDE

One year and some twenty five printed pages have finally brought Dr Scott-Murray's 'Heretic's Guide to Modern Physics' to a close. Considering that he holds a Ph.D in a physics subject it is hard to believe that he could have expected to get away with some of the things asserted there. Thus almost everyone working with oscillating systems is aware that in them energy is continually changing to and fro between kinetic and potential forms, while the total energy remains nearly constant. According to quantum mechanics the total energy of an electron bound in a hydrogen atom is quantised and therefore constant, but its kinetic energy is not. In attempting to score a point against quantum theory Dr Murray in his very first article *(Wireless World)* June 1982, p81, col 1, question and answer session) glossed over, not only the distinction between the kinetic and the total energy of the electron, but also the distinction between its angular momentum, which is quantised, and its linear momentum, which for a hydrogen atom may take a range of values that according to the uncertainty principle is inversely proportional to the mean distance of the electron from the proton, a spread thoroughly checked experimentally. Anyone indulging in such antics can hardly complain if at this point the discussion takes on 'a testiness of tone'.

Dr Murray asserted time and time again that no experiments bearing on his 'heresies' have been performed, but when faced with the results of experiments made with gamma rays from radioactive sources adopted Nelson's tactics for dealing with information he didn't wish to know about. As an aerial designer he might at least be expected to take an interest in the polar diagrams for atomic and nuclear phenomena, but when discussing the Compton effect (December 1982) he ignored this aspect of the topic completely. Nowhere does he give even a hint that the quantized angular momentum of, say, a hydrogen atom, is closely associated with the complexity of the polar diagram of any photon emission from the atom about the direction of its axis of spin. This type of association has been confirmed by many measurements on radioactive nuclei aligned at low temperatures, and by angular correlation measurements, but on the evidence of his articles the nature, interpretation, and significance of such experiments appears to be a closed book to him.

www.americanradiohistory.com

LETTERS

In attempting to justify the notion that microphysics is determinate in retrospect (March 1983, p 45) Dr Murray selected his example with some care. If he had considered instead the two-slit interference experiment with electrons, then there are arguments which show that an experimental arrangement which defines the slit through which any particular electron passes destroys the interference pattern on the far side of the slits. Thus coupled observations of an electron as it leaves the source and as it subsequently passes some point in the shadow zone between the geometrical images of the two slits do not make it possible to say through which slit the electron passed. The Copenhagen doctrine to which he is so bitterly opposed asserts that if you can't tell which way the electron went with the baffle and slits present you are not logically entitled to conclude that it must have travelled by the direct path if similar observations are made with the baffle removed.

In the April 1983 issue Dr Murray questioned the existence of the neutrino and of discrete energy levels in nuclei. The existence of the latter is demonstrated by the spectra of the alpha particles emitted by many of the natural radioactive elements. The fact that some of them emit groups of alpha particles with several well-defined and distinct energies was known long before he took his degrees. As for the neutrino, measurements on nuclei recoiling after beta decay show that in general the nucleus does not recoil in the opposite direction to that in which the beta particle is ejected, so that from the conservation of linear momentum some other particle must be present. The energy of decay can then split between the electron and the neutrino in any way consistent with the conservation of total energy of linear momentum, since the linear momentum of a free particle is *not* quantized. Dr Murray's statement (p.61, col. 1) that 'according to the new ideas the mechanics of everything small is also quantized' is far too sweeping. There is no space here to go into the dramatic experimental consequences of the fact that the angular momenta of all the particles concerned in beta decay are quantized, and that in beta decay parity is not conserved. Incidentally parity was not invented by the nuclear theorists (p.62, col. 3), and in fact has well defined values for the electric and magnetic field distributions generated by dipole and by loop aerials, to come back to Dr Murray's own field.

On the same page he quoted a text book account of the use of virtual processes in calculations. These processes are used according to well defined rules, and always occur in cascaded pairs the overall effect of which is to satisfy the conservation laws. If permissible virtual processes are arbitrarily omitted from a calculation the results will not in general be in agreement with experiment, demonstrating in another way that the indeterminacies of quantum theory reflect the properties of the natural world, and do not simply arise from the limitations of experimental techniques.

Finally we come to Dr Murray's account of the experiments carried out by Dr Aspect and his colleagues in Paris in an attempt to resolve a clash between certain predictions of quantum mechanics and of Special Relativity. In the May letters I included a reference to their own account of their work given in Physical Review Letters[1], which includes a summary of the theoretical results, such as the Bell inequality, which their experiments were designed to test, and a very clear description of the experimental arrangements, which might almost be described as classical, give or take a couple of lasers and the use of photon counters. If Dr Scott-Murray had bothered to look up that reference instead of relying on second hand accounts he would have spared himself and *Wireless World* the dubious honour of having produced the most garbled discussion of a key scientific experiment that has been seen for many years. There are indeed none so blind as those who will not see.

References

(1) A. Aspect, P. Grangier, and C. Roger, *Phys. Rev. Lett.* 47(1981) 460.

C. F. Coleman,
Grove, Nr Wantage,
Oxfordshire.

The author replies:

Mr R. J. Lamb (*WW* letters, August) says that any attempt to prove the Causality law on the lines proposed in my March '83 article must involve a circular argument. He is right, of course; that is why I followed immediately with the reminder that one cannot prove that law, nor indeed any law in physics. What I sought to do was to transfer the burden of proof, so that I would no longer be required to prove that Causality held, but instead could challenge my opponents to prove – experimentally – that it did *not* hold. Was I successful?

I go along also with James A. MacHarg (Letters, July) when he says that my arguments are "so shallow and superficial that they merely invite argument from the specialists of this world". (However, I wouldn't agree that they are subjective arguments; I think they are as firmly based on experimental evidence as anything else in physics, and much more firmly based than, say, ψ-waves or quarks). The problem has been to state the case and précis enough material to support it within a limit of about 30,000 words. For every paragraph that reached print in *Wireless World* there is to hand about ten times as mcuh backing material, and if anyone wants to go deeper into specifics in a constructive spirit he will certainly be welcome.

On the other hand, Mr M. J. Niman (July) is annoyed with me for attempting to mislead your "gullible readers" by misquoting Dirac on the antimatter concept. Dirac went in for positive charge, he says, not negative matter. But did I misquote him? What Professor P. A. M. Dirac, F.R.S., actually wrote (in the second paragraph of Proc. Roy. Soc. *167*, p.148, 1938) was:

> "Secondly, we have the [Dirac] theory of the positron – a theory in agreement with experiment so far as is known – in which positive and negative values for the mass of an electron play symmetrical roles. This cannot be fitted in with the electromagnetic idea of mass, which insists on all mass being positive, even in abstract theory."

Not much doubt about that; also the term "abstract theory" is interesting. The whole paper is greatest fun and should be prescribed reading for heretics. Mr Niman seems to have been unaware of the fanciful nature of his high priest's real views.

The purpose of my articles was not to review the sequence of argument and counter-argument that led to the establishment of the Copenhagen paradigm. That sequence is accessible in every textbook, where the student will find all the successes of current theory fulsomely recounted but only rarely, between the lines, any hint of the truth that all may not be well. He will find there no consideration of how big a photon might be, or of the structure of an electron, or of the nature of electric charge or electron spin, or of the mechanism of polarization. Adherents of the theory simply decline to discuss such matters, and seek to patronize or ridicule anyone who does. Very soon one comes to realise just how restricted the coverage of this theory is, and how little it has to say even within the field it claims to cover.

Thus Mr C. F. Coleman, who would seem to have assumed the mantle of Defender of the Faith in these columns (May, July, and now), has raised many points which show the superiority of quantum theory over the earlier, "classical" physics. Several of his points I have already dealt with, superficially I admit, in letters and in the text of the articles themselves. But I question the relevance of any of them to my heresy, since I am not advocating a return to Victorian ideas. I am merely suggesting that we should look now for a credible alternative to the quantum/wave theory, with the accent on the "credible". However, since Mr Coleman has twice provided literary reference to Dr Alain Aspect's 1981 paper (and has suggested that I did not even read it before misleading *Wireless World* readers), perhaps I had better analyse that most recent E-P-R experiment at the next level of detail as shortly as possible, from the heretical viewpoint. The following amplifies my June article.

Rather than use "annihilation" photons, which are high-energy gamma rays whose polarizations cannot be measured (why not, I wonder?), Aspect *et al* generated pairs of associated photons of visible light by means of a cascade process in the spec-

www.americanradiohistory.com

trum of calcium atoms. These photons travelled in opposite directions away from the point of generation, and their planes of polarization where measured (i.e., inferred statistically) by passing them through polarizers. The performance of each polarizer, filter and detector was measured separately, together with the losses inherent in the light-collection system; from these calibrations the statistical correlation to be expected between the photons' polarizations *as measured* could be calculated, on the assumption that the photons were polarized identically when radiated. This "prediction" is the sinusoidal curve in the second figure.

The experimental measurements fitted this "prediction" perfectly. The apparatus as a whole performed during the experiments exactly in accord with the calibrations of the two photons of any given cascade pair were closely correlated. That is what this experimental result says, and that is *all* it says. It doesn't seem to conflict with Special Relativity, or to depend upon ψ-waves, or to have to do with wave-mechanics at all. As Mr Coleman remarked, "the experimental arrangements might almost be described as classical".

Then why the fuss? I will tell you. It has got firmly into the heads of all these people that Bohr and Heisenberg were right, in that *the result of a measurement* performed on one photon of a pair must affect *the physical polarization* of its distant sibling. (A metaphysical quantity is misidentified with a physical quantity). Some weird "action", it is claimed, must pass from one detector to the other faster than the speed of light. In an attempt to rationalize this claim a number of "locally realistic theories" have been proposed, involving the assumed properties of a mythical sub-stratum of sub-physical "hidden variables". (I tell no lies: this is what our modern physics has come to). An extra-ordinarily complicated mathematical argument known as Bell's theorem, which I confess I have not bothered to understand, says that if these "hidden variables" or their equivalents existed, the result of Aspect's experiment would not be the result he actually obtained.

What Dr Aspect has reported in the paper referred to by Mr Coleman is the failure of Bell's theorem. Some people say this proves that the postulated "action" travelled through the apparatus faster than light. Dr Aspect himself did *not* say this, and neither do I. Perhaps Mr Coleman does?

Aspect's experimental result can be explained simply and naturally on classical or on slightly neo-classical reasoning. But now, *just watch* how fast a house of cards collapses! The experiment has disproved Bell's theorem, which was concerned with "locally realistic theories", which were based on "hidden variables", which were invented to support the argument of the "reduction of the wave-packet", which a specious take-it-or-leave-it consequence of the supposed existence of "ψ-waves", which in their turn were an elaboration into pseudo-scientific fantasy of an innocent speculation by a post-graduate student in 1925 . . .

Everybody nowadays should keep his Occam's razor handy. Using it, if one is not blinded by the conventional prejudice, one sees that Dr Aspect's experiment is just another nail in the coffin of the Copenhagen theory. It seemed to me that his contribution to the common weal was important enough to rate a mention, superficial though perforce it had to be, in the final article of the Heretic's Guide series. I am grateful to Mr Coleman for giving me this opportunity to explain why.

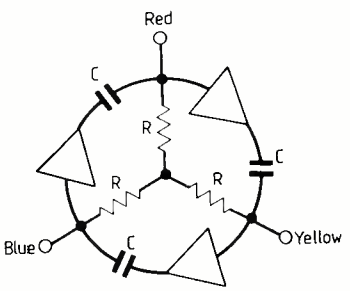
Scott Murray
Kippford
Galloway

ELECTRIC CHARGE FROM A RADIO WAVE

I am at a loss to know whether Professor Jennison was really serious in writing this article, for the conclusions he draws from his experiment seem somewhat extended.

The experimental apparatus he describes is an electronic polyphase generator, being 8-ph or 32-ph, according to how you count the nodes. As is well known in the art, polyphase machines are associated with rotating fields, and if what is normally the stator is driven backwards at synchronous speed, its field pattern will be stationary with respect to the laboratory floor. However, apart from that being an example of relative motion, what can be deduced from it? The complexity of Professor Jennison's apparatus goes some way to mask a well-known principle, the multistage phase-shift oscillator. With two stages we have the multivibrator, but with three or more a near sine-wave generator may result. The diagram shows a 3-stage RC oscillator, or should it be more properly a 3-ph generator? That depends on the purpose to which it is put. Clearly, if it is used in its 3-ph capacity, it will have when mechanically stationary, an associated rotating field. That field can be stopped by suitable mechanical rotation but can we draw any conclusions about field and charge from that?

If indeed we wish to freeze a travelling wave on a transmission line, then it is in principle easier to adopt the proposal in the letter from R. J. Hodges, also in the August issue. Admittedly that pattern came from a pulse generator at the left hand end of the line, but it could just as easily have come from energy received by an aerial.



As for all that 3K stuff, that is just confusion worse confounded.

Chris Parton
Dept. of Electrical and Electronic Engineering
Bell College of Technology
Hamilton

TECHNOLOGY AND PEOPLE

Those who have read Prof. H. J. Campbell's most excellent book The Pleasure Areas (Eyre Methuen) will be fully aware that the analogy between electronics and the brain is very much stronger than a mere apparency: Campbell, a neurophysiologist of no mean standing, makes it clear that everything we do is done ultimately for stimulation of the pleasure areas which have evolved out of the "smell brain" of the fish.

Apparently there is stimulation from the peripheral receptors (broadly the senses): there is stimulation from the movement of muscles: and above all, there is stimulation from the thought processes at work in the vast neo-cortex that makes us different to the lesser beasts.

This latter point is where the importance comes in of the pyramid programme which I mentioned in my letter of February this year – it provides a very wide base of information wherefrom an entry into genuine abstraction becomes possible, whereas that entry is impossible from a narrow specialistic base simply because the subject does not have enough information to think about, i.e. to compare: indeed the "research" of a genuine specialist tends to be little more than a good old grope in the dark!

Obviously, the more information one has to think about the more interested one becomes in systems outside one's animalistic self: Adam was more like a wasp that will not be taught to keep out of the marmalade: Cain killed Abel to appease his own introvert jealousy: Lamech's ego caused him to think that he could dispose of whom he wished. On the other hand, Noah may be thought of as the first extrovert creative, not only saving the animals two by two, but planting the first vineyard and then, sadly, imitating a newt! Obviously he still had some interest in his own material pleasures.

To put it plainly, Noah was the first to get some way into the abstract with due stimulation of his frontal lobes. Campbell makes it clear that this stimulation is *electrical*, and electrical activity in the brain is the one sure sign of remaining life.

Action, the verb of the sentence, has

www.americanradiohistory.com

three dimensions: speed, priority, and direction. These three dimensions will qualify fully any action at all. What is interesting here is that any emergency (or any threat, real or imagined) brings about an increased sense of priority, and that priority is to the self in the sense of survival; I have long believed that the autist is in a mental state of high priority, a sort of absolute "converger".

As I see it, this priority may stem from two possible causes, the one being genetic, and the other perhaps from (shock) interaction with the environment, as it appears that it must be with all matters of intelligence. I remember seeing one autist on television many years ago who could do virtually nothing but play the flute: in this respect he could be considered not unlike what one imagines an absolute specialist would be like, and as far as communication goes, appeared to display the sort of symptoms which one might expect.

Your words about the blocking effect of too much information, and the removal of stress for communication, do suggest to me that the subject needs to be taught to use the function of "comparison" in a state of relaxation, because "comparison" is the thought process at work: it is also an electrical stimulation to the pleasure areas which might help to break down the unscalable vertices bounding the existing preferred pathways for electrical signals in the brain, and so assist the subject to "break the shell", and arouse natural curiosity over a wider spectrum.

The three basic functions of any computer (at abstract level) are perception (i.e. the intake of information), memory (the storage of the information) and comparison by which it is processed. If one thinks of a simple diode gate, the one that gets there first biases off the others: the action is one of comparison through time. Thinking inspection demonstrates that these three dimensions must have evolved in that order: it appears perhaps that the autist may have failed to evolve his function of comparison, or else have some kind of block against using it.

However, as Campbell mentions, the new-born babe is born with hardly any neo-cortex having developed – it is virtually an animal – and the cortex develops with the input of sensory information of one kind or another: might not the function of comparison be assisted to evolve with patience?

It is important to realise that an efficient function of comparison will actually call for information to process so that pleasure may be obtained from the electrical stimulation which ensues: it is my own belief that it is the frustration of this information-seeking in a society which pressurises "what" but seldom teaches "how" and "why" that causes creativity to twist into animal introversion such as hooliganism and crime, away from that understanding that brings care and responsibility in its wake from an interest in systems outside the self.

As to your use of the word "mind", may I suggest that "mind" is brain plus information taken in and processed? Thus "mind" would tend to be the overall integration of electrical activity within the brain, and demonstrable by the effects of that electrical activity in that it ultimately controls all our behaviour patterns.

For those interested in the subject of intelligence and creativity generally I unhesitatingly recommend Arthur Koestler's "Act of Creation" and "The Dragons of Eden" by Carl Sagan: but Campbell's "Pleasure Areas" is some kind of vital starting point.

Finally, I would like to congratulate Mr Young over his efforts within a specialistic society which itself seems to me to demonstrate at least mild symptoms of autism!

J. A. MacHarg
Wooler
Northumberland

THE NEW BUREAUCRACY

I note that I am not the only one to dispute Ivor Catt's various assertions. The small comfort afforded by such sentiment is, however, offset by the impertinence of the man in presuming to judge a stranger's qualifications and experience. His assumption that there is some link between von Neumann and large-scale integration is of some slight interest to the psychologists, but of no relevance to the rest of us.

His loyalty test – which I am quite prepared to do – confuses small-minded bureaucratic bungling with the job at hand, which is to rid us of the pernicious von Neumann arctitecture which he so despises. He – and MAPCON – still have not realised that machine architecture need have little to do with its technological implementation. To object to their insistence in the first place. Does this insistence block the development of parallel-array machines? Of his own wafer-scale integration techniques? (I do, incidentally, deny that any programmer was responsible for the statement he quotes – programmers think in terms of structure, not composition).

The von Neumann hand that feeds me is a difficult slave and worse master, the result of an unholy marriage of mathematical theorem-proving and "if it works, it's perfect" business approaches. I do not mind biting the hand of that bastard child, for I am not fed by it, but by those who ask me to tame it. I should regard its passing with equanimity if its successor is the sort of beast which allows dealing with sets of data, rather than bytes.

Let us sort out technology from architecture. Then we can start discussing the alleged antipathy between programmers and engineers – which starts with the architecture. Until then, the battle lies between him and his simple-minded bureaucrats.

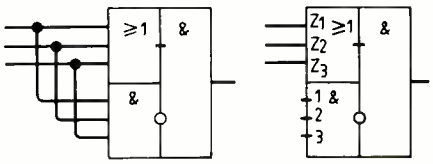
D. W. Scott
Challeston Ltd
Nettlestead Green
Kent

MIXED LOGIC

M. Butler's article on the use of mixed logic (*WW*, July 1983, pp.28 ff.) should be mandatory reading to anyone studying, or even teaching, digital techniques. He clearly emphasizes the often overlooked distinction between the actual working of circuit and its logical function(s).

M. Butler should, however, have made a passing reference to the IEC system of symbols for logical gates, that was started around 1970, and is now of standard use at such giants as the Philips and Texas Instruments. It became official norm in Germany in 1976, and also in The Netherlands. May I infer that BS followed suit? And when is *WW* to switch?

As to Mr Rudge's Letter (p.51), may I suggest the following alternatives. They are self-explanatory, I suppose.



J. Eyckmans
Sint-Truiden
Belgium

CALL SIGN

I was interested to read of the call sign 2MT on the Amateur Radio page of the August issue of *Wireless World*.

I have a copy of Harmsworth's Wireless Encyclopedia and, although it is undated, Sir Oliver Lodge writes in the introduction, ". . . to what is now in 1923 . . .".

The call sign 2MT is listed as belonging to 'Marconi Scientific Instrument Co., near Chelmsford Station, for specially authorised transmissions to amateurs.'

Another item is a 'Hanging Set': how to make a receiving set with simple controls suspended from the ceiling and giving light for the table as well as entertainment. The valves are the ordinary bright emitter type (Marconi-Osram R valves). Six valves are used – two stages of r.f. amplification, one detector valve and three stages of low frequency amplification.

Keith Ellis
Spondon
Derby

www.americanradiohistory.com

NEW PRODUCTS

HOSPITAL RADIO TRANSMITTER

With 'WW' emblazoned on the front of it, Wireless Workshop produce a medium wave transmitter for use in hospitals, universities and other private services. Using loop transmitting aerials throughout the buildings covered, the transmissions can be picked up on ordinary receivers. The four modules, all fitting together into a standard rack, are an audio processor, an m.f. exciter, a low-distortion v-mos linear amplifier in the cable distribution circuit, and a d.c. power unit. Each transmitting loop has its own, independently controllable, loop driver allowing the system to be accurately tailored to suit the reception area. The units may be purchased separately, so the audio unit could be used with other transmitters, while the wide bandwidth and low distortion (according to 'WW') of the m.f. exciter makes it useful for testing a.m. receivers. Wireless Workshop, 25 Ditchling Rise, Brighton, E. Sussex BN1 4QL.
WW 301

WW 301

MACHINE-CODE MONITORS

Basic in personal computers has its limitations and much more computer commands at a higher speed are obtainable if the user is prepared to the computers own operating language or 'machine-code'. To make this easier software programs allow the display of a computer's memory and allow programs to be entered and displayed in their machine code format and sometimes in the mnemonics used to make this numerical language more intelligible. One such program is the N-Bug, written by Kuma for the Newbrain computer. With it, a single display shows a complete memory dump which may be scrolled through, the display also shows the state of each register, and a screen editor allows programs to be entered easily, altered and corrected. Other features include hexadecimal/decimal interconversion, relative jump calculations and the setting of breakpoints. Another display screenful offers menu selection of printer and tape input/output and allows the saving, verifying and loading of machine-code programs. N-Bug is complemented by Zen an assembly language editor/assembler; both are available from Kuma Computers Ltd, 11 York Road, Maidenhead, Berks SL6 1SQ.

A very similar program, written this time for the Oric-1 computer, is the Extension Monitor by Kenema Associates. There are some useful additional facilities; the ability to step through a program, to search for byte or character strings, to set or eliminate breakpoints. Other commands may be defined by the user. Hexadecimal display also 'translates' any character codes embedded in it and displays these in a separate column. A disassembled mnemonic display is included. Kenema Associates Ltd, 1 Marlborough Drive, Worle, Avon BS22 0DQ.
Kuma WW 302
Kenema WW 303

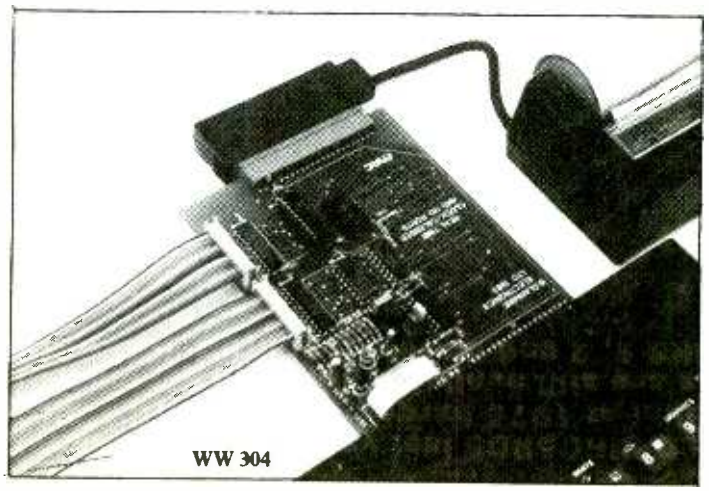
REAL-TIME CLOCK FOR SINCLAIRS

A time controller for the ZX81 and Spectrum computers has been developed in Ireland. The battery-backed circuit can control eight inputs and eight outputs and also provides the computer with date and time, including seconds. The controller has its own rom program and only a single instruction is needed from the computer to give the date and time. The circuit plugs directly into the computer's expansion port and provides another port for the addition of a ram pack, printer or other peripheral. It may be used as an electronic diary, with an alarm for important appointments; as a controller for household appliances or intruder alarms; to time sound effects or games and in process control, laboratory experiments etc. The version for the ZX81 costs £34.50 and for the Spectrum, £38.50. Glanmire Electronics Ltd, Westley House, Trinity Avenue, Bush Hill Park, Enfield, Middlesex EN1 1PH.
WW 304

MASS MEMORY IN SOLID STATE

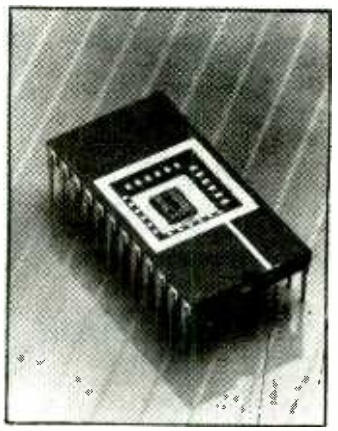
Plugging into the disc drive port of many popular computers, the MegaRAM storage unit offers memory capacity of between 1 and 32M-bytes. The advantages of using solid state memory, according to the distributors, is that it operates much faster than magnetic discs; and this is particularly noticeable when running programs with a lot of input/output activity, such as data base management, file sorting and merging and similar tasks. Another advantage is the lack of any moving parts, hence better reliability and no noise. At the end of a computing session, the memory can be copied onto a disc for long-term storage.

The MegaRAM circuitry includes automatic error checking and correction for any single-bit errors. An optional power supply includes battery back-up giving time to transfer the contents to back-up storage in the event of a mains failure. Compass Peripheral Systems, 67 Milford Road, Reading, Berks RG1 8NA.
WW 305


WW 304

D-TO-A CONVERTER RUNS COOL

Monolithic construction and low power dissipation make the DAC80 run a lower operating temperatures and allow the use of low-cost plastic packaging, claim Analog Devices.



The 12-bit converter with selectable voltage output has also claimed for it a higher reliability, a wider temperature range, and more accuracy than those of competing models. Analog Devices Ltd, Central Avenue, East Molesley, Surrey KT8 0SN.
WW 306

FSK MODEM ON A CHIP

To construct a low speed modem (300 or 600bit/s) all that is needed is the XR-14412 integrated circuit and a few external components. The crystal-controlled circuit can operate simplex, half or full-duplex modes with self-test and echo facilities. It needs a single supply rail and inputs and outputs are t.t.l. or c-mos compatible. Using a suitable transformer, the modem can connect directly to a telephone line or may be used with an acoustic coupler. For phase-shift key (p.s.k.) modems a self-contained bandpass filter is available, the XR 2120. Full details of both from Rastra Electronics Ltd, 275 King Street, London W6 9NF.
WW 307

www.americanradiohistory.com

TOROIDAL TRANSFORMERS

Fully encased in an ABS plastic shell, the ILP range of lower power toroidal transformers have been produced in answer to public demand. Starting at 15VA, available now, the range is to be extended to provide transformers up to 120VA. ILP Electronics Ltd, Graham Bell House, Roper Close, Canterbury, Kent CT2 7EP.
WW 308

BENCH POWER

A series regulated power pack can give a constantly variable output between 0 and 18V, and 0 to 5A. Coarse and fine manual controls are provided or the output may be controlled by an external potentiometer. The Trio PR 655 is provided with two large meters to indicate current and voltage. A fixed current protection circuit may be switched in; as can regulated current or voltage operation. Remote sensing is possible and the supply may be configured in a series or parallel, master or slave mode. House of Instruments, Clifton Chambers, 62 High Street, Saffron Walden, Essex CB10 1EE.
WW 309

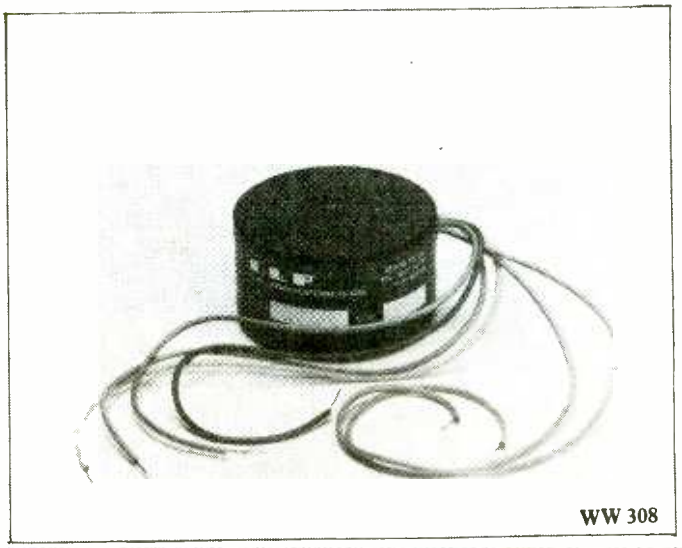
LOW POWER SOLID-STATE LASER

A series of monolithic GaAs GaAlAs pulsed lasers has been extended to include the LA5-02, with an output of 6W peak at a wavelength of 905nm. The emitted beam width of 150μm makes it suitable for proximity detection, ranging and security systems. STC Components, Laser Unit, Brixham Road, Paignton, Devon TQ4 7BE.
WW 310

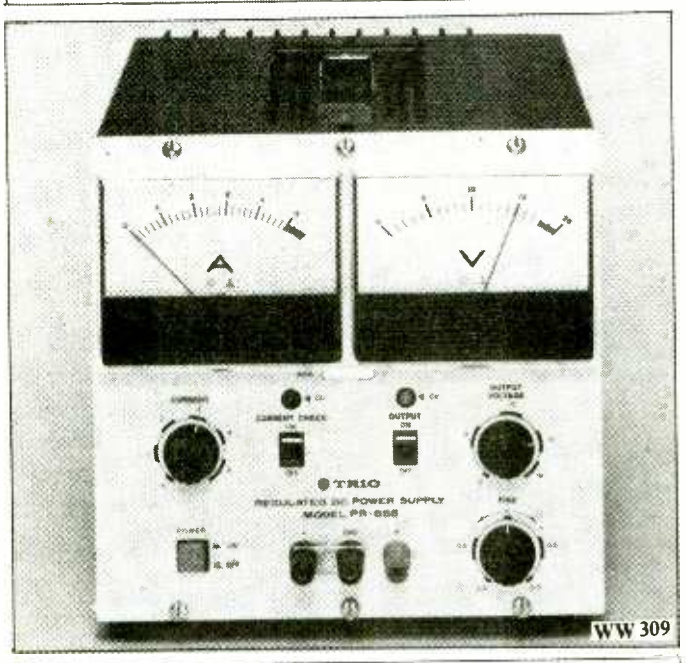
COMPUTER CONNECTOR KIT

Suitable for RS232 and V24 computer interfaces, a kit of housings, contacts, cable clamps and extraction and crimping tools can be used for rapid repair or replacement and in experimental use. It will help to overcome those frustrating moments when the plug on a cable doesn't fit the socket on the peripheral. Ampliversal, Terminal House, Stanmore, Middlesex HA7 4RS.
WW 311

If you would like more information on any of the items featured here, enter the appropriate WW reference number(s) on the mauve reply-paid card bound in this issue. Overseas cards require a stamp.



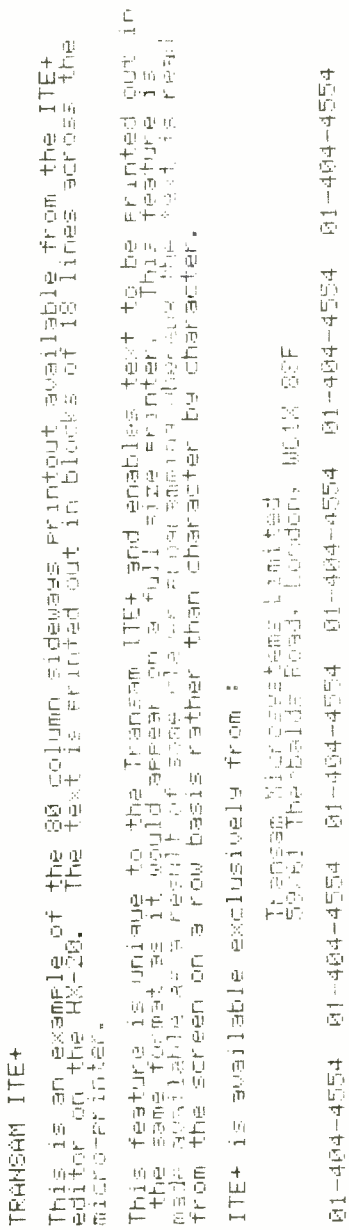
WW 308



WW 309

WW 311

SIDEWAYS PRINT ON EPSON MICRO



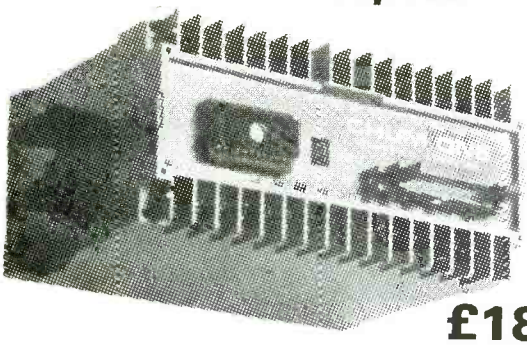
WW 312

NON-VOLATILE RAM

A 16K static ram that has a miniature lithium back-up battery is claimed to last for more than five years. The battery is contained within the ram package and the device fits a standard 24 pin socket and can replace any existing 16K ram or 2716-type eproms, at a similar price. The MK48Z02 comes from Mostek UK Ltd, 1 Valley Drive, Kingsbury Road, London NW9.
WW 313

www.americanradiohistory.com

CHUM ONE
Industrial Computer



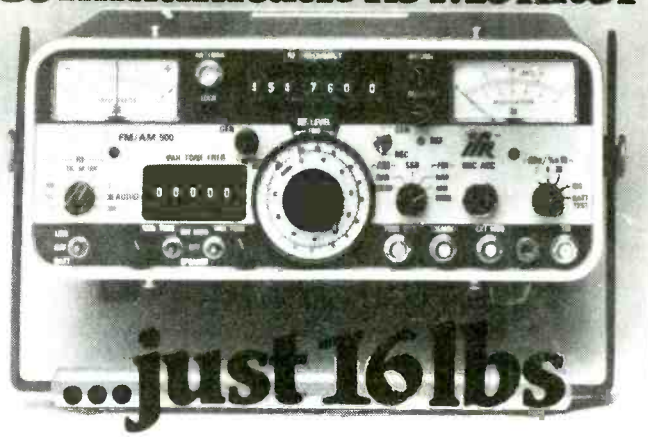
£189

- ★ Basic and Z80 Assembly Language
- ★ Detachable Hand-Held Keyboard
- ★ 8K Bytes of Non-Volatile Memory
- ★ 8 Analogue Inputs
- ★ 1 Analogue Output
- ★ Up to 512 Optical Coupled Inputs/Outputs
- ★ 4 Programmable Frequency/Timers
- ★ Serial Input/Output Port
- ★ Real Time Clock
- ★ 32-Character by 2-line Display
- ★ Software:
  - Machine Control
  - Thermocouple
  - Data Log
  - Weighing machine

WARWICK DESIGN GROUP, 12 ST. GEORGE'S ROAD LEAMINGTON SPA CV31 3AY (0926) 34311

WW – 037 FOR FURTHER DETAILS

Your own customised Communications Monitor



The vast range of available options allows you to customise the FM/AM 500 Micro-Monitor to suit your specific needs, and weighing in at just 16 lbs your 'field-tests' can now be precisely that!

For a practical demonstration to prove our point contact:-

Mike Dawson on 01-897 6446.

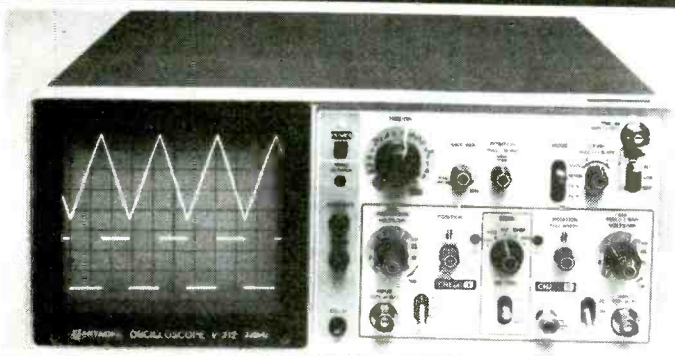
Hunting

Fieldtech Heathrow

Fieldtech Heathrow Limited
Huntavia House 420 Bath Road
Longford Middlesex UB7 0LL
Telex: 23734 FLDTEC G

WW – 029 FOR FURTHER DETAILS

Hitachi Oscilloscopes
performance, reliability, value



New Models!
immediate delivery!

New from Hitachi are three low-cost bench 'scopes with bigger screens and extra features in a new slimline ultra-lightweight format. The range now extends to 13 models:—

- **4 dual trace single timebase models 20MHz to 40MHz**
- **2 dual trace sweep delay models 20MHz and 35MHz**
- **2 dual timebase multi-trace models 60MHz and 100MHz**
- **2 miniature field portable models, 20MHz and 50MHz**
- **3 storage models, one tube storage, two digital storage**

Prices start at £295 plus vat (model illustrated) including 2 probes and a 2-year warranty. We hold the range in stock for immediate delivery.

For colour brochure giving specifications and prices ring **(0480) 63570.**

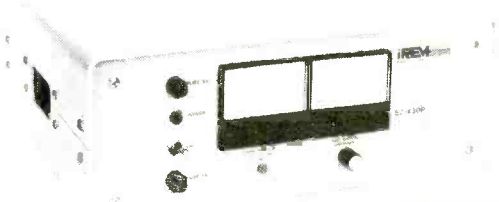
Reltech Instruments, 46 High Street, Solihull, W. Midlands, B91 3TB

WW – 046 FOR FURTHER DETAILS

ELECTRONIC POWER UNITS
FOR XENON ARC AND MERCURY ARC LAMPS

UNITS AVAILABLE FOR LAMPS RANGING FROM 75 TO 6500 WATTS.

Lamp housings and lens systems manufactured as standard off the shelf models or to specific design.



K. T. Manners Design Ltd.

P.O. Box 936, London, W4 4NW Telephone: 01-994 7155. Telex: 28604

WW – 048 FOR FURTHER DETAILS

Bird Electronic

THRULINE® Wattmeters

TERMALINE® loads

and accessories from stock

Aspen Electronics Limited

The exclusive
UK representative for Bird Electronic

2/3 Kildare Close, Eastcote,
Ruislip, Middlesex HA4 9UR
Telephone: 01-868 1188
Telex: 8812727

WW – 050 FOR FURTHER DETAILS

www.americanradiohistory.com

Discover the Microcomputer Age

Come along to The Northern Computer Fair and discover for yourself the excitement of the microcomputer age. All you need to know about personal computers, home computers and microcomputer systems for business will be on display at Belle Vue, Manchester from November 24-26. All your questions will be answered at the North's premier personal computer exhibition.

Enthusiasts can see the latest software and hardware technology in action, and for those new to the world of computers this show is a great introduction. Being sponsored by Practical Computing and Your Computer, the leading microcomputing magazines, you can be sure of value for money at £3 a ticket for Adults and £2 for Children under 16.

Travelling to the show is also easy as the organisers have arranged special reduced-price tickets with British Rail which include the cost of admission. For further information ring British Rail Enquiry Bureau on 061-832-8353 before November 11.

The Northern Computer Fair is open between 10.00 am and 6.00 pm every day so come along and bring the microcomputer age alive for you.

For special party rates and further information contact:
The Exhibition Manager,
The Northern Computer Fair,
Reed Exhibitions, Surrey House,
1 Throwley Way, Sutton,
Surrey SM1 4QQ

Sponsored by:

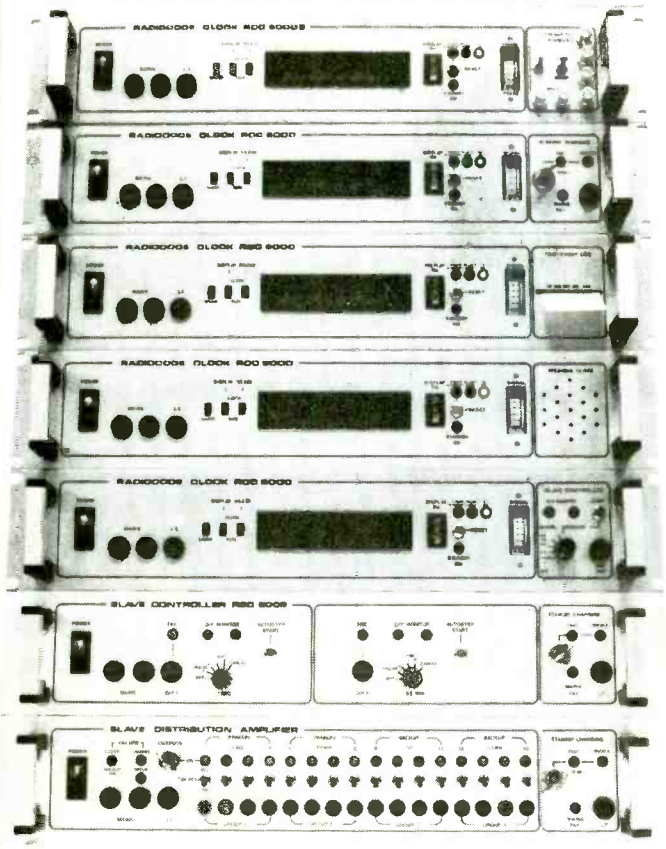
Practical Computing and YOUR COMPUTER

WW – 043 FOR FURTHER DETAILS

www.americanradiohistory.com

RADIOCODE CLOCKS SOLVE PROBLEMS

ATOMIC TIME, FREQUENCY AND SYNCHRONISATION EQUIPMENT



NEW PHASE-MODULATION SYSTEMS

Until recently, atomic time and date information was only available on v.l.f. transmissions using amplitude modulation. The RCC 8000AM series of equipment uses these transmissions to offer high noise immunity and high accuracy, particularly at very long range.

The new RCC 8000PM series of equipment uses, for the first time, phase modulated tranmissions with massive radiated powers of up to 2 Mega-Watts to offer long range, excellent noise immunity and no scheduled maintenance periods.

NEW PRODUCTS

The AM and PM series of Radiocode Clock equipment has been further expanded to include seven new models (from top) **8000S** – combined clock, frequency standard and optional stopclock. **Internal standby power supply** – with dual rate constant current charger. **Time-event log** – prints hours, minutes, seconds, milliseconds and day of year, on receipt of a log pulse. **Speaking clock** – time announcement or audio recording. **Slave controller** – total control of single-standard master/slave systems ie one pulse/sec. **Dual standard slave controller** – total control of two different and independent slave systems, ie. one pulse/sec and one pulse/half min. **Slave distribution amplifier** – maximum flexibility for the largest master/slave installations requiring dual standard operation, multiple circuits and complete master/slave backup.

NEW OPTIONS

A continuously expanding range of fully integrated software and hardware is available for both series of Radiocode Clock equipment. Standard options now include:

- IRIG B precision serial o/p
- RS232/V24 1mS resolution
- General purpose parallel o/p
- FSK record/replay system
- Keypad entry of alarm times
- Keypad entry of time/date
- Time code generators
- Intelligent slave systems
- Standard frequency outputs
- Stopclock operation
- Calibrated systems for increased accuracy

Radiocode Clocks Ltd*
Unit 19, Parkengue, Kernick Road Industrial Estate
Penryn, Falmouth, Cornwall. Tel: Falmouth (0326) 76007
(*A Circuit Services Associate Co.)

WW – 025 FOR FURTHER DETAILS

CUBE Your partner in electronic enterprise

Share in the Success Story of *Industrial* Microcomputing.
The spectacular growth in the use of microcomputers in the home, in education and in the office is merely the overture to the real revolution – the micro-computerisation of industry.

Your role as an OEM
If you are planning a product which includes microprocessor control, then CUBE modules can both perform the development task *and* be economically configured as part of the end product. Development time and costs will be radically reduced because of the high level of performance that already exists in CUBE. Delivery time of a finished product to your customers can be reduced from months to weeks. Technical support? Your engineers will have direct access to our Cambridge design team responsible for the entire CUBE range.

Your role as a Distributor
The CUBE concept is now becoming widely known as a result of press coverage, advertising and for its success stories in industrial implementations. CUBE modules are such good value and so flexible that they can be profitably incorporated into nearly every electronic control application. Your task as a distributor is to present the latest developments to potential users and advise on product customisation using CUBE products.

Control Universal Limited is a company with a solid reputation for designing and manufacturing computers in Cambridge. An impressive record of growth both in sales and in the range of products offered allows us to offer a solution to nearly every machine and process control application. Full details of the CUBE range, and how they are now fully supported by software tools (such as BBC BASIC and FLEX cross-compilers) are in our catalogue, free on request.

Let's work together and aim for electronic industrial control for a more prosperous world!

Please write to me directly:
Jon Dane, Managing Director
Control Universal Ltd., Unit 2, Andersons Court
Newnham Road, Cambridge CB3 9EZ
telephone: 0223–358757 telex: 995801–G, GLOTX

Control Universal Ltd
The Hardware House

WW – 044 FOR FURTHER DETAILS

www.americanradiohistory.com

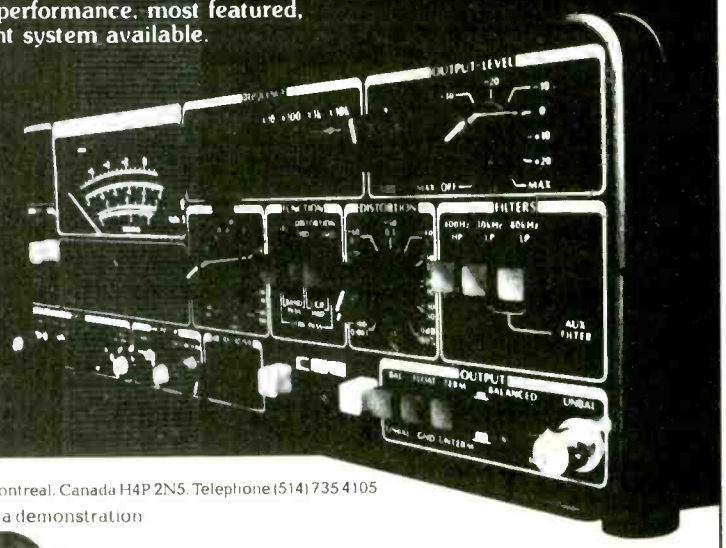
Looking for a Distortion Measurement System?

The Amber model 3501 is quite simply the highest performance, most featured, yet lowest cost audio distortion and noise measurement system available.

It offers state-of-the-art performance with THD measurements to below 0.0008% (−102dB), maximum output level to +30dBm and noise measurements to below −120dBm.

It has features like automatic operation, optional balanced input/output and powerful IMD measurement capability. It includes comprehensive noise weighting with four user changeable filters. Unique features like manual spectrum analysis and selectable bandwidth signal-to-noise measurements.

The 3501 is fast, easy to use and its light weight and small size make it very portable. It can even be battery powered.



amber Amber Electro Design Inc. 4810 Jean Talon West, Montreal, Canada H4P 2N5. Telephone (514) 735 4105

Ring to-day for a demonstration

Scenic Sounds Equipment Limited

97-99 Dean Street, London W1V 5RA Telephone: 01-734 2812/3/4/5 Telex: 27 939 SCENIC G

Worldwide Export: Gotham Export Corporation, 741 Washington Street New York NY10014

WW – 033 FOR FURTHER DETAILS

The Wings Appeal Fund helps to maintain the RAF Association Home for Disabled and Chronic Sick. Care is essential for those who have served their country and who are in need. So please help by giving all you can for an emblem in WINGS WEEK in September or send a donation to show that you care.

Give as they Gave

To: Royal Air Forces Association, Appeals Dept., (DS) Portland Rd., Malvern, Worcs. WR14 2TA.

I enclose a donation of_____ for the Wings Appeal Fund.

Name_____

Address_____

Please tick if receipt required ☐ or information on RAFA Membership ☐

Space donated by Wireless World

MANUFACTURERS & DISTRIBUTORS

"LESLIE" TREMELO SPEAKER SYSTEM

A two-speed rotating baffle system which when used as part of an Organ, Hi-Fi or Disco System produces the famous **LESLIE** effect. The unit comes complete with a 50watt 8 ohms speaker at peak output, two 220/240v 50 Hz motors with central drive to rotating Horn/Baffle, this gives a three-way sound effect i.e. normal tremelo sound when stationary, wraparound sound when revolving at 1 rev per sec and supersound at 7 revs per sec. Baffle size 485mm x 395mm. Overall depth from speaker magnet to central boss of rotating horn/baffle 300mm approx. £200 for 5, £360 for 10, £825 for 25, £1,500 for 50, £2,700 for 100. Sample sent for £45 + £5 P&P (£57.50 inc. VAT).

ORGAN KEYBOARDS

High Quality 54-note keyboard manufactured by **FATAR** in Italy. Keys are mounted on a pressed steel frame with steel springs on each key. Note Range "C" to "C" £100 for 5, £180 for 10, £410 for 25, £775 for 50. Sample keyboard sent for £25 + £3 P&P (£32.20 inc. VAT).

TWIN KEYBOARD AND FRAME

Two 37-note "C" to "C"

Keyboards mounted on a plastic frame. Keyboards are offset by one octave and are hinged for easy adjustment. Manufactured by **FATAR**. £175 for 5, £315 for 10, £710 for 25, £1,275 for 50. Sample sent for £40 + £4 P&P (£50.60 inc. VAT).

STEREO CASSETTE FRONT LOADING REPLAY MECHANISM for in-car entertainment, complete with motor and preamplifier. Manufactured in UK under Licence of Staar, S.A. £45 for 10 + VAT, £205 for 50 + VAT, £375 for 100 + VAT. Sample for £5 + £1.50 P&P (£7.48 inc. VAT).

MONO DYNAMIC MICROPHONE AND STAND, 3.5mm J plug fitted to approx. 1m lead £7 for 10 + VAT, £32 for 50 + VAT, £60 for 100 + VAT, £270 for 500 + VAT, £500 for 1,000 + VAT. Sample sent for £1 + 50p P&P (£1.38 inc. VAT).

REVERSIBLE GEARED MOTOR, manf. by CROUZET, 8 rpm 240 volt 50 Hz with universal T drive. £35 for 10 + VAT, £162 for 50 + VAT, £300 for 100 + VAT, £1,250 for 500 + VAT. Sample sent for £3.75 + 75 P&P (£5.17 inc. VAT).

ELECTRONIC EQUIPMENT CO.

SPRINGFIELD HOUSE
TYSSEN STREET, LONDON E8
TEL: 01-249 5217
TELEX: 8953906 EECO.G

www.americanradiohistory.com

U.K. RETURN OF POST MAIL ORDER SERVICE, ALSO WORLDWIDE EXPORT SERVICE

RECORD DECKS
SINGLE PLAY
Large Turntables
240 volt AC. Post £2

Make	Model	Drive	Cartridge	Price
BSR	P170	Rim	Ceramic	£20
GARRARD	6200	Rim	Ceramic	£22
GARRARD	Delux	Belt	Magnetic	£40
GOLDRING	G102	Belt	Magnetic	£30
BSR	P232	12 volt	Magnetic	£24
AUTOCHANGERS 240 VOLT				
BSR	Budget	Rim	Ceramic	£16
BSR	Delux	Rim	Ceramic	£18
BSR	Delux	Rim	Magnetic	£26

MAINS PRE-AMP FOR MAGNETIC CARTRIDGES to low gain amplifier 10mv to ½ volt, mono **£5**, stereo **£7**. P&P £1

HEAVY METAL PLINTHS
Post £1
Cut out for most Garrard decks. Black or silver grey finish. Size 16×13¾in. **£4**

DECCA TEAK VENEERED PLINTH. Post £1
Superior finish with space and panel for small amplifier. Board is cut for B.S.R. 18¾in.×14¼in×4in. Black/chrome facia trim. Also with boards cut out for Garrard £3. **Tinted plastic cover £5** **£5**

TINTED PLASTIC COVERS Post £1

17⅞×13⅛×3¼in.	£5	18¼×12½×3in.	£5
17¼×9⅜×3½in.	£3	14⅜×12½×2⅞in.	£5
16½×15×4½in.	£5	16⅝×13×4in.	£5
17×12⅞×3½in.	£5	14½×13⅛×2¾in.	£5
22⅝×13⅞×3in.	£5	17¼×13¾×4⅛in.	£5
21½×14¼×2½in.	£5	21×13⅞×4⅛in.	£5
23¾×14×3⅞in.	£5	30¾×13⅜×3¼in.	£5

THE "INSTANT" BULK TAPE ERASER £10.50 Post 95p
Suitable for cassettes and all sizes of tape reels. AC mains 200/250V. Hand held size with switch and lead (120 volt to order). Will also demagnetise small tools and computer tapes.
Tape Head Demagnetiser only £5.

BATTERY ELIMINATOR MAINS to 9 VOLT D.C.
Stabilised output, 9 volt 400 m.a. U.K. made in plastic case with screw terminals. Safety overload cut out. Size 5×3¼×2½in. Transformer Rectifier Unit. Suitable Radios, Cassettes, models, **£5**. Post £1

DRILL SPEED CONTROLLER/LIGHT DIMMER KIT. Easy build kit. Controls up to 800 watts AC mains with plastic case 4×3×1½in, **£5**, less case **£4**. For brush motors, power tools, drills and lighting. Post 65p.

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS £3.95. Post 65p
All parts and instructions with Zener diode printed circuit, mains transformer 240V a.c. Output 6 or 7½ or 9 or 12V d.c. up to 100mA. Please state voltage required

RELAYS. 6V DC **95p.** 12V DC **£1.25.** 18V **£1.25.** 24V **£1.30**
ALUMINIUM CHASSIS. 2½in deep 6×4–**£1.75;** 8×6–**£2.20;** 10×7–**£2.75;** 12×8–**£3.20;** 14×9–**£3.60;** 16×6–**£3;** 16×10–**£3.80;** 12×3 **£2.20;** 14×3 **£2.50;** 13×9 **£2.80.**
ALUMINIUM PANELS. 6×4–**55p;** 8×6–**90p;** 14×3–**90p;** 10×7–**£1.15;** 12×8–**£1.30;** 12×5–**90p;** 16×6–**£1.30;** 14×9–**£1.75;** 12×12–**£1.80;** 16×10–**£2.10.**
ALUMINIUM BOXES. 4×4×1½ **£1.20.** 4×2½×2 **£1.20.** 3×2×1 **£1.20.** 6×4×2 **£1.90.** 7×5×3 **£2.90.** 8×6×3 **£3.** 10×7×3 **£3.60.** 12×5×3 **£3.60.** 12×8×3 **£4.30.**
ALI ANGLE BRACKET 6×¾×¾in. **30p.**
BRIDGE RECTIFIER 200V PIV 2a **£1.** 4a **£1.50.** 6a **£2.50.**
TOGGLE SWITCHES SP **40p.** DPST **50p.** DPDT **60p.**
MINIATURE TOGGLES SP **40p.** DPDT **60p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, **2p;** 2W **10p.** Low ohm 1 watt 0.47 to 3.9 ohm **10p.**
HIGH STABILITY. ½w 2% 10 ohms to 1 meg. **10p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **20p.**
PICK-UP CARTRIDGES SONOTONE 9TAHC **£3.80.**
BSR Stereo Ceramic SC7 Medium Output **£2.** SC12 **£3.50.**
PHILIPS PLUG-IN HEAD. Stereo Ceramic. AU1020 (G306 -GP310 - GP233 -AG3306, **£2. A.D.C., QLM 30/3 Magnetic £6.50.**
STYLUS most Ceramic Acos, Sonotone, BSR, Garrard Philips,**£1.50** ea. Send old one for quote.
MAGNETIC STYLUS, Sony, JVC, Sanyo, Goldring, etc. **£4.**
LOCKTITE SEALING KIT DECCA 118. Complete **£1.**
VALVE OUTPUT Transformers push/pull 15 watt **£14;** 30W **£18;** 50W **£20;** 100W **£24.** Post £2. 100V/Line 20W **£3.75.**
SPEAKER MATCHING TX 4 to 8 or 8 to 4 ohm 15 watt **£3.**
MICROSWITCH, 50p, Miniature **65p.** SPDT.
ANTEX SOLDERING IRON 'C' 15W **£5.25.** 25W 'X25' **£5.50.**
WAFER SWITCHES. 1¼" dia. Long Spindle **60p ea.**
1P 12W; 2P 2W; 2P 6W; 3P 4W; 4P 2W; 4P 3W.
FERRITE ROD. 6"×½", 6"×⅜", 8×5/16" **50p**
XLR Lead Plug **£2.40.** Lead socket **£2.75**
XLR Chassis Plug **£2.20.** Chassis Socket **£2.55.**
BANANA 4mm Plugs/Sockets, red/black **20p**
JACK PLUGS Mono Plastic **25p;** Metal **30p.** Sockets **25p.**
JACK PLUGS Stereo Plastic **30p;** Metal **35p.** Sockets **30p.**
FREE SOCKETS – Cable end **30p.** Metal **45p.**
2.5mm and 3.5mm **JACK SOCKETS 25p. Plugs 25p.**
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin **15p.** Free Sockets 3-pin, 5-pin **25p.** Plugs 3-pin **20p;** 5-pin **25p;** Speaker plugs **25p;** Sockets **15p.**
PHONO PLUGS and SOCKETS ea. **20p;** Double sockets **30p.** Free Socket for cable end **20p.** Screened Phono Plugs **25p.**
B.N.C. PLUGS £1. Sockets **£1.** Free Sockets **£1.10.**
U.H.F. PLUG 50p. Socket **50p.** Reducer **20p.** Coupler **50p.**
300 ohm TWIN RIBBON FEEDER 10p yd.
300 ohm to 75 ohm AERIAL MATCHING TRANSFORMER £1.
U.H.F. COAXIAL CABLE SUPER LOW LOSS, 75 ohm **25p yd.**
COAX PLUGS 30p. COAX SOCKETS 20p. Lead Sockets 65p.
NEON INDICATORS 250V, round **40p.** Rectangular **45p.**
MORSE CODE TAPPER AND BUZZER SET £3.
CAR CASSETTE MECHANISM. 12V Motor Stereo Head **£5**

POTENTIOMETERS Carbon Track
5kΩ to 2MΩ. LOG or LIN. L/S **50p.** DP **90p.** Stereo L/S **£1.10.** DP **£1.30.** Edge Pot 5K. SP **45p.**

MINI-MULTI TESTER NEW
De luxe pocket size precision moving coil instrument. Impedance + Capacity – 4000 o.p.v. Battery included.
11 instant ranges measure:
DC volts 5.25, 250, 500.
AC volts 10, 50, 500, 1000.
DC amps 0-250μA, 0-250mA.
Resistance 0 to 600K ohms.
£7.50 Post 65p

De Luxe Range Doubler Model £19.50
50,000 o.p.v. 7×5×2in. Post £1
43 Ranges, 1,000V, AC-DC, 20 meg, etc.

PANEL METERS
50μa, 100μa, 500μa, 1ma, 5ma, 50ma, 100ma, 500ma, 1 amp, 2 amp, 25 volt, VU
2¼×2×1¼. Stereo VU 3¼×1⅝×1in. **£4.50** Post 50p

RCS SOUND TO LIGHT CONTROL BOX
Complete ready to use with cabinet size 9×3×5in. 3 channel, 1000 watt each. For home or disco **£27** Post £1
OR KIT OF PARTS £19.50

LIGHT BOXES, 20x9x9in, red, yellow, blue, green, **£16.**
DISCO BULBS 100 watt, blue, green, yellow, red, amber, screw or bayonet **£2** each. Post £1.50 per six.
"FUZZ" lights, red, blue, green, amber, 240V. **£28.** Post £1.
200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4,** or 12 for **£7.50.** Post £1.50. Suitable panel mounting holders **85p.**

RCS "MINOR" 10 watt AMPLIFIER KIT £14
This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£14;** Stereo, **£20.** Post £1
10W per channel; size 9½×3×2in. SAE details.
Full instructions supplied. 240V AC mains.

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board **£3.50**
Can be ganged to make multi-way stereo mixers Post 65p

MAINS TRANSFORMERS
Post

250-0-250V 30mA, 6.3V 3.5A, 6.3V 1A	£6.00	£2
350-0-350V 250mA, 6.3V 6A CT	£12.00	£2
220V 25ma 6V lamp £3.00	220V 45ma 6V 2 Amp £4.00	£1
250V 60mA, 6V 2A	£4.75	£1

Step-Down 115V to 240V 150W **£9.** 250W **£10.** 500W **£12.00** £2

GENERAL PURPOSE LOW VOLTAGE

Tapped outputs available	Price	Post		Price	Post
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V				£8.00	£2
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60				£8.00	£2
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60				£10.50	£2
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60				£12.50	£2
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60				£16.00	£2
5-8-10-16V. ½ amp.	£2.50	£1	15-0-15V. 1 amp	£4.00	£1
6V. ½ amp.	£2.00	£1	15-0-15V. 2 amps	£4.50	£1
6-0-6V. 1½ amp.	£3.50	£1	20V 1 amp	£4.00	£1
9V. 400ma.	£1.50	£1	20-0-20V 1 amp	£4.50	£1
9V. 3 amp	£4.50	£1	20-40-60V 1 amp	£4.50	£2
9-0-9V. 50ma	£1.50	£1	25-0-25V 2 amps	£5.50	£2
9-0-9V. 1 amp	£3.50	£1	28V 1 amp Twice	£6.00	£2
10-0-10V. 2 amps	£4.00	£1	30V 1½ amp	£4.50	£1
10-30-40V. 2 amps	£4.50	£1	30V 5 amp and 17-0-17 2a	£5.50	£2
12V. 100ma	£1.50	£1			
12V. 750 ma	£2.50	£1	35V 2 amps	£4.50	£1
12V 3 amps	£4.50	£1	TOROIDAL 30-0-30V 4a and 20-0 20V ½a	£8.50	£2
12-0-12V. 2 amps	£4.50	£1			

CHARGER TRANS	Post	RECTIFIERS	Post
6-12 volt 3a	£4.50+£2	6-12 volt 2a	£1.10+80p
6-12 volt 4a	£6.50+£2	6-12 volt 4a	£2.00+80p

OPUS COMPACT SPEAKERS £18 pair Post £2

TEAK VENEERED CABINET
11×8½×7in, 15 watts. 4, 8 or 16 ohm
OPUS TWO 15×10½×7¾in 25 watt 2-way system **£39 pair.** Post £3
GOODMANS Q70 8 ohms 70 watt 3 way with Mid & Treble controls, **£70.** PP £4

LOW VOLTAGE ELECTROLYTICS Wire ends All 10p ea
1 mf, 2 mf, 4 mf, 8 mf, 10 mf, 16 mf, 25 mf, 30 mf, 50 mf, 100 mf, 250 mf. All 15 volts. 22 mf/6v/10v; 25 mf/6v/10v; 47 mf/10v; 50 mf/6v; 68 mf/6v/10v/16v/25v; 100 mf/10v; 150 mf/6v/10v; 200 mf/10v/16v; 220mf/4v/10v/16v; 330 mf/4v/10v; 500 mf/6v; 680 mf/6v/10v; 1000 mf/2.5v/4v/10v; 1500 mf/10v; 2200 mf/6v/10v; 3300 mf/6v; 4700 mf/4v.
500mF 12V **15p;** 25V **20p;** 50V **30p.** 1200mF 76V **80p.**
1000mF 12V **20p;** 25V **35p;** 50V **50p;** 100V **£1.20p.**
2000mF 30V **42p;** 40V **60p;** 100V **£1.40;** 1500mF 100V **£1.20.**
2200mF 63V **90p.** 2500mF 50V **70p;** 3000mF 50V **85p;**
4700mF 30v **75p;** 40v **£1;** 63v **£1.80.**

NON POLARISED CAPACITORS – REVERSIBLE
1mF 250V **25p;** 1.5mF 100V **25p;** 2.2mF 250V **30p;** 3.3mF 100V **40p;** 4.7mF 100V **40p;** 10mF 63V **40p;** 32mF 50V **25p.**

HIGH VOLTAGE ELECTROLYTICS

2/500V	45p	32+32+16/350V	90p	8+16/450V	75p
8/450V	45p	100+100/275V	50p	16+16/350V	80p
16/350V	45p	150+200/275V	50p	32+32/350V	85p
32/500V	95p	32+32+32/325V	50p	32+32/500V	£2
32/350V	50p	50+50+50/350V	95p	50+50/300V	50p
50/450V	95p	8+8/500V	£1	50+50/350V	80p

CAPACITORS WIRE END High Voltage
.001, .002, .003, .005, .01, .02, .03, .05 mfd 400V **10p.**
.1MF 400V **14p.** 600V **15p.** 1000V **25p.**
.22MF 350V **12p.** 600V **20p.** 1000V **30p.** 1750V **60p.**
.47MF 150V **10p.** 400V **25p.** 630V **30p.** 1000V **60p.**
TRIMMERS 30pF, 50pF, **10p.** 100pF, 150pF **20p.** 500pF **30p.**
MICROSWITCH SINGLE POLE CHANGEOVER 40p.
GEARED TWIN GANGS 365+365+25+25pF **£2.**
BRASS SPINDLE EXTENDERS 85p. Couplers **65p.**
VERNIER DRIVE DIALS, 36mm **£2.50,** 50mm **£3.**
SLOW MOTION DRIVE 6:1 £1.50. Reverse Vernier drive 90p.
TWIN GANG 25+25pF or 120+120pF **£1**

HEATING ELEMENTS, WAFER THIN (Semi Flexible)
Size 11×9×⅛in. Operating voltage 240V, 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, Propagation, etc. Must be clamped between two sheets of metal or ceramic, etc.
ONLY **60p** EACH (FOUR FOR **£2**) POST 50p.

NEW baker Star sound

High power full range quality loudspeakers. British made. Ideal for Hi-Fi, music P.A. or discotheques. These loudspeakers are recommended for high power quality.

MODEL	INCHES	OHMS	WATTS	TYPE	PRICE	POST
MAJOR	12	4-8-16	30	HI-FI	£16	£2
SUPERB	12	8-16	30	HI-FI	£26	£2
AUDITORIUM	12	8-16	45	HI-FI	£24	£2
AUDITORIUM	15	8-16	60	HI-FI	£37	£2
GROUP 45	12	4-8-16	45	PA	£16	£2
DG 75	12	4-8-16	75	PA	£20	£2
GROUP 100	12	8-16	100	PA	£26	£2
DISCO 100	12	8-16	100	Disco	£26	£2
GROUP 100	15	8-16	100	PA	£35	£2
DISCO 100	15	8-16	100	Disco	£35	£2

BAKER AMPLIFIERS BRITISH MADE

NEW PA150 MICROPHONE PA AMPLIFIER £129
4 channel 8 inputs, dual impedance, 50K-600 ohm 4 channel mixing, volume, treble, bass. Presence controls, Master volume control, echo send return socket. Slave sockets. Post £3.

BAKER 150 Watt AMPLIFIER 4 Inputs £99
For Discotheque, Vocal, Public Address. Three speaker outlets for 4, 8 or 16 ohms. Four high gain inputs, 20 mv, 50K ohm. Individual volume controls "Four channel" mixing. 150 watts 8 ohms R.M.S. Music Power. Slave output 500 M.V 25Kohm. Response 25 Hz – 20kHz ± 3dB. Integral Hi-Fi preamp separate Bass & Treble. Size – 16"×8"×5½". Wt – 14lb: Master volume control. British made. 12 months' guarantee. 240v A.C. mains or 120V to order. All transistor and solid state. Post £2.
100 Volt Line Model £114. MONO SLAVE 150 watt £80.
New Stereo Slave 150 + 150 watt 300 watt Mono £125. Post £4.

BAKER MOBILE PA AMPLIFIER. All transistor, 60 watt RMS, 12v DC & 240v AC, 4 inputs 50k. Aux + 2 mics + 1 phono. Outputs 4-8-16 ohm + 100 volt line, **£89** p.p. £2

BAKER PORTABLE DISCO 150w. Twin console + amplifier + mike and headphones + twin speakers **£300.** 300 watt version Complete **£399.** Carriage £30. Console with pre-amp only **£107**

ELECTRONIC ECHO CHAMBER £85. Post £2
BBD Delay System 30 m/sec to 200 m/sec. Variable echo and direct sounds. Maintenance free. 240V AC.

DISCO GRAPHIC MIXER EQUALISER £108. Post £2
4 Channel stereo, 5 band graphic, red + green LED, VU display, headphone monitor, or Deluxe Model **£119.**

PA CABINET SPEAKERS, Complete. 8 ohm 60 watt 17×15×9in. **£25.** Post £4. 4 or 8 or 16 ohm 75 watt 23×15×11in. **£50.** 90 watt 32×15×11in. **£63.** 120 watt **£77.** Carr. £10. Black vinyl covered with handles.
WATERPROOF HORNS 8 ohms. 25 watt **£20.** 30 watt **£23.** 40 watt **£26.** 40W plus 100 volt line **£32.** Post £2.

R.C.S. 100 watt R.M.S. VALVE AMPLIFIER
4 Channel mixing. Master treble, bass and volume controls. 5 Speaker outlets, suits 4, 8, 16 ohm, Disco group. **£125.** Carr. & ins. £15.
60 WATT VALVE AMPLIFIER,
3 mixer inputs, 4-8-16 ohm, 100 volt line. 5 controls, 2 mic inputs plus 1 input switchable for mic, phono, aux. Treble and bass and 3 volume controls, 7 valves. **£69.** Post £3.

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

MAKE	MODEL	SIZE	WATTS	OHMS	PRICE	POST
WHARFEDALE	TWEETER	4in	30	8	£7.50	£1
PEERLESS	TWEETER	3¾in	60	8	£6.50	£1
AUDAX	TWEETER	4in	30	8	£6.50	£1
AUDAX	MID-RANGE	4in	50	8	£7.50	£1
SEAS	MID-RANGE	4½in	100	8	£14.50	£1
AUDAX	WOOFER	5½	25	8	£10	£1
GOODMANS	HIFAX	7½×4¼	100	4/8/16	£30	£2
GOODMANS	WOOFER	8in	25	4/8	£7.50	£1
GOODMANS	HB WOOFER	8in	60	8	£12.50	£1
WHARFEDALE	WOOFER	8in	30	8	£9.50	£2
CELESTION	DISCO/GROUP	10in	50	8/16	£19	£2
GOODMANS	HPG/GROUP	12in	120	8/15	£29.50	£2
GOODMANS	GR12/GRDUP	12in	90	8/15	£27.50	£2
GOODMANS	HPD/DISCO	12in	120	8/15	£29.50	£2
GOODMANS	HP/BASS	15in	250	8	£72	£3
GOODMANS	HPD/BASS	18in	230	8	£84	£4

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
B.A.F. LOUDSPEAKER CABINET WADDING 18in wide 35p ft.

MOTOROLA PIEZO ELECTRIC HORN TWEETER, 3⅜in. square **£5**
100 watts. No crossover required. 4-8-16 ohm, 7⅜×3⅛in. **£10**

CROSSOVERS. TWO-WAY 3000 c/s 30 watt **£3.** 100W **£4.**
3-way 950 cps/3000 cps. 40 watt rating. **£4.** 60 watt **£6.** 100W **£8.**
LOUDSPEAKER BARGAINS. Please enquire, many others in stock.
4 ohm, 5in, 7×4in, **£2.50;** 6½in, 8×5in, **£3;** 8in, **£3.50.** 6½in 20W **£7.50.**
8 ohm, 2⅝in, 3in, **£2;** 5×3in, 6×4in, 7×4in, 5in, **£2.50;** 6½in, 20W **£7.50** 8×5in, **£3;** 8in, **£4.50;** 10in, **£5;** 12in, **£6.** 8in 25W **£6.50**
15 ohm, 2¼in, 3½in, 5×3in, 6×4in, **£2.50.** 6½in 10W **£5.** 8in **£4.** 10in **£7.**
25 ohm, 3in, **£2;** 5×3in, 6×4in, 7×4in, **£2.50.** 120 ohm, 3¼in dia. **£1.**

EMI 13½x8in. SPEAKERS

Model 450A, 10 watts R.M.S. with moving coil tweeter and two-way crossover, 3 ohm or 8 ohm. "Final Clearance" **£8** Post £1.50
SUITABLE BOOKSHELF CABINET
Teak Veneers **£6.50.** Size 18×11×6in. Post £1.50

RADIO COMPONENT SPECIALISTS

Dept 1, 337 WHITEHORSE ROAD, CROYDON
Open 9-6. Closed all day Wed. Open Sat. 9-5.

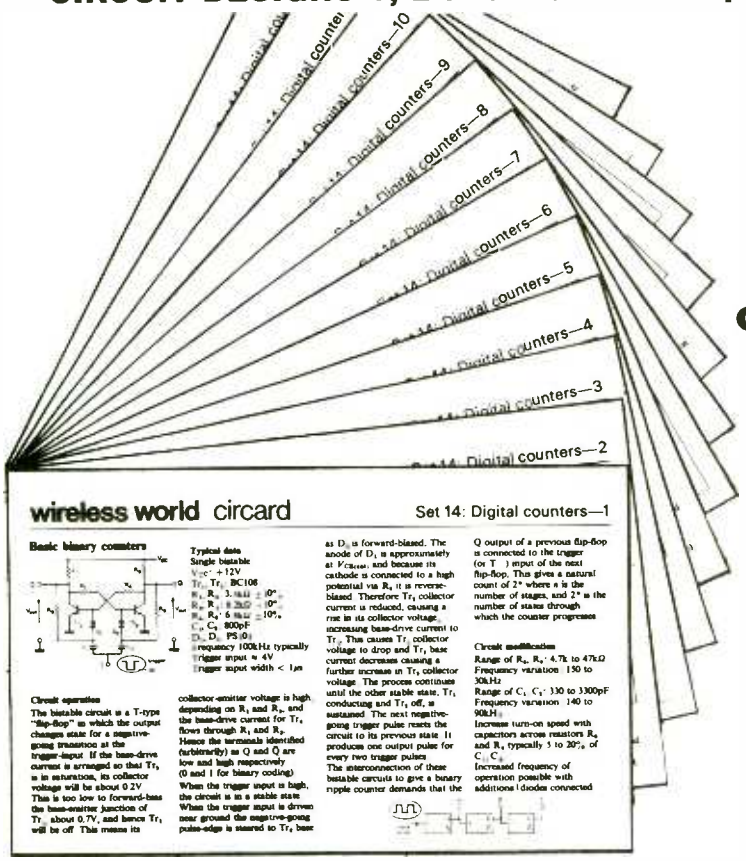
Books and Components Lists 32p stamps. (Minimum post/packing charge 65p.) Access or Barclaycard Visa. Tel: 01-684 1665 for SAME DAY DESPATCH. Cash prices include VAT.

WW-7

www.americanradiohistory.com

MARK 1983 WITH GAPS IN CIRCUIT FILES WELL-PLUGGED

WIRELESS WORLD CIRCARDS last year benefited many 'new generation' readers who bought at 1976 bargain prices + 10% discount for 10 sets! Most sets are still available although companion volumes CIRCUIT DESIGNS 1, 2 and 3 are out of print (CIRCARDS sets 1 to 30).



The Offer stands, so order now your sets of 127 × 204mm cards in plastic wallets. These unique circuit cards normally contain descriptions and performance data of 10 tested circuits, together with ideas for modifying them to suit special needs.

1 Basic Active filters 2 Switching Circuits, comparators and Schmitts (But these gaps cannot be filled) * 6 Constant current circuits 7 Power amplifiers 8 Astable circuits 9 Optoelectronics 10 Micro power circuits 11 Basic logic gates 12 Wideband amplifiers 13 Alarm circuits 14 Digital Counters 15 Pulse modulators 16 Current differencing amplifiers – signal processing 17 Current differencing amplifiers – signal generation 18 Current differencing amplifiers – measurement and detection 19 Monostable circuits 20 Transistor pairs 21 Voltage-to-frequency converters 22 Amplitude modulation and detection 23 Reference circuits 24 Voltage regulators 25 RC oscillators – 1 26 RC oscillators – 2 27 Linear cmos – 1 28 Linear cmos – 2 29 Analogue multipliers 30 Rms/log/power laws 31 Digital multipliers 32 Transistor arrays 33 Differential and bridge amplifiers 34 Analogue gate applications – 1 35 Analogue gate applications – 2.

*Photocopies only: 3 Waveform generators 4A.C. measurement 5 Audio circuits @ £3.20 each set.

To Electrical-Electronic Press
General Sales Department
Room 108
Quadrant House
Sutton
Surrey SM2 5AS

Please send me the following sets of Circards.....£2 each, £18 for 10 post free.

Remittance enclosed ..... payable to BUSINESS PRESS INTERNATIONAL LIMITED

Name (Please print) .....

Address (Please print).....

.....

Company Registered Number: 151537 (ENGLAND). Registered Office: Quadrant House, The Quadrant Sutton, Surrey SM2 5AS

www.americanradiohistory.com

VALVES

Minimum Order £1

VALVES VAT IS INCLUDED

A1065	1.40	EF39	1.25	MH4	2.50	PY83	0.80	Z749	0.75	6AX4GT	1.30
A2293	8.80	EF80	0.65	ML6	2.50	PY88	0.60	Z800U	3.45	6AX5GT	1.30
A2900	13.75	EF83	1.75	N78	9.90	PY500A	2.10	Z801U	3.75	6BA6	0.55
AR8	0.75	EF85	0.60	OA2	0.70	PY809	6.45	Z803U	16.00	6BE6	0.60
ARP3	0.70	EF86	0.75	OB2	0.80	PY801	0.80	Z900T	2.45	6BG6G	1.60
ATP4	0.60	EF89	1.05	PABC80	0.60	QQV03/10	3.20	1A3	0.85	6BJ6	1.30
B12H	3.90	EF91	1.50	PC85	0.75		7.50*	1L4	0.50	6BQ7A	0.85
CY31	1.40	EF92	2.90	PC86	0.85	QQV03-20A		1R5	0.60	6BR7	4.80
DAF96	0.70	EF95	0.65	PC88	0.90		21.50	1S4	0.45	6BW6	6.20
DET22	28.50	EF96	0.60	PC97	1.25	QQV03-25A		1S5	0.45	6BW7	1.80
DF96	0.70	EF183	0.80	PC900	0.90		36.50	1T4	0.45	6C4	0.50
DH76	0.75	EF184	0.80	PCC84	0.50	QQV06/40A		1U4	0.80	6C6	0.55
DL92	0.60	EF812	0.75	PCC89	0.85		16.10	1X2B	1.40	6CH6	8.20
DY86/87	0.65	EFL200	1.85	PCC189	0.85	QV03-12	4.20	2X2A	2.50	6CL6	2.75
DY802	0.70	EH90	0.85	PCF80	0.80	SP61	1.80	3A4	0.70	6CW4	8.50
E92CC	2.80	EL32	1.10	PCF82	0.70	TT21	23.00	3AT2	2.40	6CX8	3.80
E180F	7.70	EL34	1.80	PCF84	0.75	TT22	23.00	3B28	12.00	6CY5	1.15
E182CC	6.25		2.90*	PCF86	1.50	U25	1.15		19.50*	6D6	0.70
EA76	2.25	EL37	5.20	PCF87	0.50	U26	1.15	3D6	0.50	6F6	1.60
EABC80	0.80	EL82	0.70	PCF200	1.45	U27	1.15	3D22	23.00	6F6GB	1.10
EB91	0.60	EL84	0.80	PCF201	1.65	U191	0.85	3E29	19.00	6F7	2.80
EBC33	1.15	EL86	0.95	PCF800	0.50	U281	0.70	3S4	0.60	6F8G	0.85
EBC90	0.90	EL90	1.00	PCF801	1.75	U301	0.65	4B32	18.25	6F12	1.50
EBF80	0.60	EL91	4.20	PCF802	0.70	U600	11.50	5R4GY	1.80	6F14	1.15
EBF83	0.60	EL95	0.80	PCF806	1.20	U801	0.90	5U4G	0.75	6F15	1.30
EBF89	0.80	EL504	1.70	PCF808	1.45	UBC41	1.20	5V4G	0.75	6F17	3.20
EC52	0.65	EL803	5.90	PCH200	1.35	UABC80	0.75	5Y3GT	0.95	6F23	0.75
EC91	4.40	EL509	3.95	PCL81	0.75	UAF42	1.20	5Z3	1.50	6F24	1.75
EC92	0.85	EL821	8.20	PCL82	0.95	UBF80	0.70	5Z4G	0.75	6F33	10.50
ECC81	0.85	EL822	9.95	PCL84	0.90	UBF89	0.70	5Z4GT	1.05	6FH8	12.50
ECC82	0.60	ELL80(SE)	2.60	PCL86	0.75	UCC84	0.85	6/30L2	0.90	6GA8	1.95
ECC83	0.65	EM80	0.85	PCL805/85	0.95	UCC85	0.70	6AB7	0.70	6GH8A	1.95
ECC84	0.60	EM87	1.30	PD500/510	4.30	UCF80	1.30	6AC7	1.15	6H6	1.60
ECC85	0.60	EY51	0.95	PFL200	1.10	UCH42	1.65	6AG5	0.60	6JU6	5.85
ECC88	0.80	EY81	0.65		2.80*	UCH81	0.75	6AH6	1.15	6J4	1.35
ECC189	0.95	EY86/87	0.60	PL36	1.10	UCL82	0.95	6AK5	0.65	6J4WA	2.00
ECC804	0.90	EY88	0.65	PL81	0.85	UF41	1.35	6AK8	0.60	6J5	2.30
ECF80	0.85	EZ80	0.70	PL82	0.70	UF80	0.95	6AL5	0.60	6J5GT	0.90
ECF82	0.65	EZ81	0.70	PL83	0.60	UF85	0.95	6AL5W	0.85	6J6	0.65
ECF801	1.05	GM4	5.90	PL84	0.95	UL84	0.95	6AM5	4.20	6J6W	0.90
ECH34	2.25	GY501	1.30	PL504	1.00	UM80	0.90	6AM6	1.50	6K7	0.80
ECH42	1.20	GZ32	1.05	PL508	2.40	UM84	0.70	6AN8A	2.50	6KD6	4.50
ECH81	0.70	GZ33	4.20	PL509	5.65	UY82	0.70	6AQ4	3.40	6L6M	2.80
ECH84	0.80	GZ34	2.75	PL519	5.80	UY85	0.85	6AQ5	1.00	6L6GC	2.65
ECL80	0.70	GZ37	3.95	PL802(SE)	2.95	VR105/30	1.25	6AQ5W	1.80	6L6GT	1.25
ECL82	0.75	KT66	7.80	PY33	0.70	VR150/30	1.35	6AS6	1.15	6L18	0.70
ECL85	0.80		11.20*	PY80	0.70	X66	0.95	6AT6	0.90	6LD20	0.70
ECL86	0.90	KT88	10.50	PY81/800	0.85	X61M	1.70	6AU6	0.60	6Q7G	1.30
EF37A	2.15		13.60*	PY82	0.65	Z759	19.00	6AV6	0.85	6SA7	1.00

VALVES AND TRANSISTORS
Telephone enquiries for valves, transistors, etc: retail 749 3934, trade and export 743 0899.

FIELD TELEPHONE, CABLE TYPE D10

HARNESS "A" & "B" CONTROL UNITS "A" "R" "J1" "J2." Microphones No 5, 6, 7 connectors, frames, carrier sets, etc.
DRUM CABLE continuous connection YC 00433.

FIELD TELEPHONES TYPE "J". Tropical, in metal cases.
10-line MAGNETO SWITCHBOARD. Can work with every type of magneto telephones.

PRICES MAY VARY

POSTAGE: £1-£3 45p; £3-£5 55p; £5-£10 60p; £10-£15 80p; £15-£20 100p.

COLOMOR
(ELECTRONICS LTD.)
170 Goldhawk Road, London W.12

Tel. 01-743 0899 or 01-749 3934
Open Monday to Friday
9 a.m.-5.30 p.m.

WW-20

Happy Memories

Part type	1 off	25-99	100 up
4116 200ns	1.25	1.15	1.10
4816 100ns For BBC comp	1.95	1.85	1.75
4164 200ns	4.20	3.75	3.60
2114 200ns Low power	1.15	1.00	.90
2114 450ns Low Power	.95	.85	.80
6116 150ns	3.35	3.00	2.85
6116 150ns Low power	4.90	4.40	4.20
2708 450ns	3.25	2.95	2.80
2716 450ns 5-volt	2.35	2.10	2.02
2716 450ns three rail	5.75	5.00	4.65
2732 450ns Intel type	3.35	3.00	2.85
2532 450ns Texas type	3.35	3.00	2.85
2764 250ns	4.20	3.75	3.60
27128 250ns	16.00	14.30	13.75

Z80A-CPU .....£2.99 Z80A-PIO .....£2.99 Z80A-CTC.....£2.99
6522 PIA .....£3.70 7805 reg.....£0.50 7812 reg.. .....£0.50

Low profile IC sockets: Pins	8	14	16	18	20	22	24	28	40
Texas solder-tail: Pence	12	13	14	16	18	22	24	27	38

Wabash soft-sectored floppy discs per 10 in plastic library case:

5-inch SSSD	£17.00	5-inch SSDD	£19.25	5-inch DSDD	£21.00
		5-inch DSQD	£26.35		
8-inch SSSD	£19.25	8-inch SSDD	£23.65	8-inch DSDD	£25.00

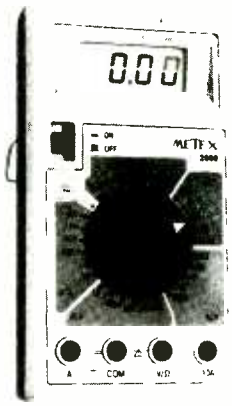
74LS series TTL, large stocks at low prices with DIY discounts starting at a mix of just 25 pieces. Write or 'phone for list.

Please add 50p post and packing to orders under £15 and VAT to total
Access and Visa welcome, 24-hr. 'phone service on (054 422) 618
Government and Educational orders welcome, £15 minimum
Trade accounts operated, 'phone or write for details

HAPPY MEMORIES (WW)
Gladestry, Kington
Herefordshire HR5 3NY
Tel. (054 422) 618 or 628

hi! performance hi! competitive hi!

Probably the
BEST VALUE FOR MONEY
DMM AT £29.50
inc P+D. VAT extra



with FREE
* **TEST LEADS**
* **BATTERY**
* **OPERATING MANUAL**
* **SPARE FUSE**

PLUS a FREE
* **CARRYING CASE**

and
* **FULLY GUARANTEED FOR 12 MONTHS**

hi! ONE large 'easy to use' rotary switch

hi! 30 protected ranges to 1000V 10 Amps and 20 Meg Ohms

hi! Other features inc. small compact hand held size – basic 0.5% accuracy – high reliability using CMOS circuitry – large clear LCD display – auto zero, polarity, overange and LO Batt. indication – diode test – tilt stand with non skid feet – high surge voltage protection etc. etc.

AVAILABLE from **HOUSE OF INSTRUMENTS** and **LOCAL DISTRIBUTORS**
Just ask for **METEX 3000 FREE DATA**

Easy to Order: Fill in and post the coupon enclosing cheque/P.O./Credit Card details or Official Order.

VISA Access AMERICAN EXPRESS

In a hurry? Then ring (0799) 24922

Name.....
Address.....
.....
Tel. No.....
Please send:
.... Metex Type 3000 at £33.93 (inc. VAT + P+D).....
.... Luxury Test Leads at £6.60 (inc VAT + P+D).....
.... Luxury Test Lead Set at £10.60 (inc VAT + P+D).....
Total £.....

Please tick and fill in number of card
Barclaycard Access American Express
Credit Card No. .....
Please allow 14 days for delivery.

House of Instruments,
Clifton Chambers, 62 High Street,
Saffron Walden, Essex CB10 1EE
Telephone (0799) 24922 Telex 818750

hi! reliability hi! service hi! performance hi! competitive

hi! reliability hi! service hi! performance hi! competitive

hi! competitive hi!

hi! House of Instruments Ltd.

WW – 020 FOR FURTHER DETAILS

www.americanradiohistory.com

01-452 1500 TECHNOMATIC LTD 01-450 6597

BBC Micro Computer System

OFFICIAL DEALER

Please phone for availability

BBC Model B **£399** (incl. VAT)
Carr £8/unit
Model A to Model B upgrade kit **£50**
Fitting charge **£15**
Individual upgrades also available

TELETEXT ADAPTOR £195
WORDWISE 8K ROM £39
TORCH Z80 DISC PACK £825

WORD PROCESSOR 'VIEW' 16K ROM £52

BUSINESS, EDUCATION AND FUN SOFTWARE IN STOCK–

FLOPPY DISC INTERFACE
incl. 1.2 Operating System
£95 & £20 installation

BBC FLOPPY DISC DRIVES
Single Drive 5¼'' 100K **£230**+£6 carr.
Double Drive 5¼'' 800K **£699**+£8 carr.

BBC COMPATIBLE 5¼'' DISC DRIVES
These drives are supplied in BBC matching colour cases and with necessary cables.
SINGLE DRIVES: 100K **£150**; 200K **£215** 400K **£265**
SINGLE DRIVES: with PSU 100K **£185**; 200K **£260***; 400K **£330**
DUAL DRIVES: with PSU 2 × 100K **£355**; 2 × 200K **£475***; 2 × 400K **£595**
***These drives are provided with a switch to change between 40 and 80 tracks.**
DRIVE CABLES: SINGLE **£8**, DUAL **£12**.
DISC MANUAL & FORMATTING DISKETTE **£12.50**

Phone or send for our BBC leaflet

CASSETTE RECORDER
SANYO Data Recorder DR101
A superior quality data recorder with dedicated computer output and monitoring facility on both record and play
£39.50 + £1.50 carr.
SLIMLINE Cassette Recorder complete with counter and remote control
£24.50 + £1.50 carr.
Computer Grade Cassettes
£0.50 each. **£4.50** for 10 + **£1** carr
Cassette lead **£3.50**.

MONITORS
MICROVITEC 1431 14in Colour Monitor **£230+£8** carr
MICROVITEC 2031 20in Colour Monitor **£319+£8** carr
KAGA 12in RGB Monitor **£255+£8** carr
Lead for KAGA/SANYO RGB **£10**
SANYO HI RES GREEN MONITOR **£99+£6** carr
SANYO HI RES RGB MONITOR **£445+£8** carr.

BBC BOOKS (no VAT; p&p £1)
Basic on BBC **£5.95**
30 House Basic **£5.95**
Programming the BBC Micro **£6.50**
BBC Micro An Expert Guide **£6.95**
Assy Lang Prog. for BBC **£8.95**
6502 Machine Codes for Beginners **£6.95**

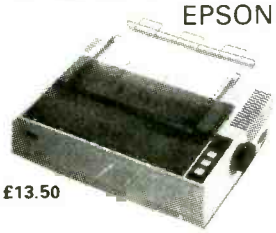
PRINTERS

NEC PC 8023 BE – N
120 CPS, 80 cols
Logic Seeking, Bi-directional
Forward and Reverse Line Feed.
Proportional Spacing, Auto Underline, Hi-Res and Block Graphics, Greek Char. Set.
Only **£320** + £8 carr.

SEIKOSHA
GP 100A **£175.00**
GP 250X **£235.00**
GP 700A **£425.00**
Silver Reed EX44 Daisy Wheel with Serial Interface
£365, with Parallel Interface **£385**
Carriage/Printer £8.00

Parallel Printer lead for BBC/Atom to most printers **£13.50**
Variety of interfaces, ribbons in stock.
2,000 fan fold sheets 9½''×11'' **£13.50**+£3 p&p

EPSON RX80 and FX80



RX 80 100CPS 80 col Tractor Feed **£270**
FX80 160CPS 80 col F & T Feed **£380**
MX100 F/T3 **£425** (Carr./printer **£8**)
NEW RX 80 FT **£319** Carriage/Printer **£8**

SIDEWAYS ROM EXPANSION BOARD
This board provides 8 high quality 28 pin sockets for expanding the computer's sideways ROM capacity by a further 128K. (As 8K Eproms consume about 40mA on standby and 16K much higher, in our opinion addition of 8 extra ROMS will not overload the computer psu nor cause internal overheating). All ROM sockets are of turned pin type gold contacts to ensure that numerous insertions and extractions will not wear out or deform them. The board is fully buffered and also dimensioned to ensure non interference with other on board components. Full fitting instructions supplied. **£25** + **£2 p&p**.

TORCH Z-80 PACK
For little more than the cost of an 800K disc drive, you can now considerably extend your BBCs capabilities. The twin drives, together with the Z80 card, gives you 64K of memory and includes a database, word processor etc. Comes complete with manuals, CP/N Operating System, Demonstration and Utility programs etc. The system is fully compatible with CP/M* thus allowing the use of professional business software. **£825** + **£8 p&p**.
Special offer from Torch: free software worth £1,000, for a limited period only and subject to availability.
*CP/M is a trademark of Digital Research.

CONNECTOR SYSTEMS

I.D. CONNECTORS
(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn.
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

	No. of ways 9	15	25	37
MALE				
Solder	80p	105p	160p	250p
Angled	150p	210p	250p	365p
FEMALE				
Solder	105p	160p	200p	335p
Angled	165p	215p	290p	440p
Hoods	90p	85p	90p	100p

IDC 25-way plug **385p**. Socket **450p**

TEXTOOL ZIF
SOCKETS 24-pin **£5.75**
28-pin **£8.00** 40-pin **£9.75**

DIL SWITCHES
4-way **70p** 8-way **90p**
6-way **85p** 10-way **140p**

JUMPER LEADS
24'' Ribbon Cable with Headers

	14-pin	16-pin	24-pin	40-pin
1 end	145p	165p	240p	350p
2 ends	210p	230p	345p	540p

24'' Ribbon Cable with Sockets

	20-pin	26-pin	34-pin	40-pin
1 end	160p	200p	280p	300p
2 ends	290p	370p	480p	525p

Ribbon Cable with D. Conn.
25-way Male **500p** Female **550p**

RS 232 JUMPERS
(25-way D)
24'' Single end Male **£5.00**
24'' Single end Female **£5.25**
24'' Female-Female **£10.00**
24'' Male-Male **£9.50**
24'' Male-Female **£9.50**

DIL HEADERS

	Solder Type	IDC Type
14pin	40p	100p
16pin	50p	110p
24pin	100p	150p
40pin	200p	225p

AMPHENOL CONNECTORS
36-way plug Centronics Parallel Solder **£5.25** IDC **£4.95**
36-way socket Centronics Parallel Solder **£5.50** IDC **£5.20**
24-way plug IEEE Solder **£5** IDC **£4.75**
24-way socket IEEE Solder **£5**

EURO CONNECTORS

	Plug	Skt.
DIN 41617		
21-way	160p	165p
31-way	170p	170p
DIN 4161Z		
2×32-way St. Pin	220p	275p
2×32-way Ang. Pin	275p	320p
3×32-way St. Pin	260p	300p
3×32-way Ang. Pin	375p	350p

TEST CLIPS
14-pin **275p** 16-pin **£3**
40-pin **£6**

RIBBON CABLE
(Grey/meter)

10-way	40p
16-way	60p
20-way	85p
26-way	120p
34-way	160p
40-way	180p
50-way	200p
64-way	280p

EDGE CONNECTORS

	0.1''	0.156''
2×18-way	–	140p
2×22-way	190p	240p
2×23-way	175p	–
2×25-way	225p	220p
2×28-way	190p	–
1×43-way	260p	–
2×43-way	365p	
1×77-way	600p	
5100 Conn		600p

DISC DRIVES FOR THE FORTH COMPUTER
5¼'' Teac FD55 Slim Line Mechanisms.
FD55A 40 track SSDD 250kbytes unformatted
Bare: **£135**; Cased: **£155**
2 × FD55A 40 track SSDD 500kbytes unformatted
Cased × psu **£350**
FD55E 80 track SSDD 500kbytes unformatted
Bare: **£180**; Cased: **£205**
2 × FD55E 80 track SSDD 1 Mbyte unformatted
Cased + psu **£475**
5¼'' Mitsubishi M4853 Slim Line mechanism 80 track
DSDD 1 Mbyte unformatted Bare: **£225**; Cased: **£245**
2 × M4853 2 Mbytes Cased + psu **£590**
Single drive cable **£8**; Dual Drive cable **£12**
Other parts for FORTH COMPUTER available send SAE for details.

NEW COMPREHENSIVE CATALOGUE AVAILABLE
PLEASE SEND FOR PRICE LIST

PRODUCTION EPROM PROGRAMMER Type P8000
It will blank check, copy and verify up to 8 Eproms at a time. Eprom types 2716 to 27128 can be selected by a single rotary switch.
£695 + £6 carriage.

★ SPECIAL OFFER ★

2532	350p
2732	350p
2764-25	450p
27128-25	£25
4164-2	450p
6116P-150NS	350p

UV ERASERS
UV1B up to 6 Eproms **£47.50**
UV1T with Timer **£60**
UV140 up to 14 Eproms **£61.50**
UV141 with Timer **£78**
(Carr £2/eraser)
All erasers are fitted with mains switches and safety interlocks.

'WIRELESS WORLD' PROJECTS
Semiconductors inc. I.Cs., Transistors, Displays, Connectors and Sockets for most projects are stocked by us

BOOKS
(No VAT p&p £1)
CRT Controller H/Book **£8.50**
Programming the Z80 ..... **£11.50**
Z80 Microcomp Handbook **£6.95**
Programming the 6502 ..... **£10.25**
6502 Assy. Lang **£12.10**
6502 Applications **£10.20**
6502 Software Design **£9.05**
6502 Games **£10.25**
Large selection of databooks, interfacing books, books on BBC, etc in stock. Ask for our list. WW-12

www.americanradiohistory.com

74 SERIES

7400 18p
7401 18p
7402 18p
7403 18p
7404 22p
7405 22p
7406 90p
7407 90p
7408 18p
7409 18p
7410 18p
7411 18p
7412 18p
7413 27p
7414 42p
7416 38p
7417 38p
7420 18p
7421 18p
7422 22p
7423 22p
7425 25p
7426 24p
7427 22p
7428 22p
7430 18p
7432 22p
7433 22p
7437 22p
7438 60p
7439 36p
7440 22p
7441 55p
7442A 40p
7444 70p
7445 75p
7446A 50p
7447A 68p
7448 65p
7450 20p
7451 18p
7453 20p
7454 20p
7460 30p
7470 30p
7472 25p
7473 25p
7474 27p
7475 32p
7476 25p
7480 48p
7481 120p
7482 90p
7483A 48p
7484A 90p
7485 90p
7486 30p
7489 170p
7490A 32p
7491 48p
7492A 36p
7493A 32p
7494 75p
7495A 38p
7496 50p
7497 120p
74100 120p
74104 50p
74105 55p
74107 27p
74109 27p
74110 45p
74111 55p
74112 170p
74116 90p
74118 90p
74119 75p
74120 75p
74121 32p
74122 36p
74123 45p
74125 34p
74126 36p
74128 45p
74132 43p
74136 38p
74141 55p
74142 175p
74143 200p
74144 200p
74145 75p
74147 90p
74148 75p
74150 120p
74151A 40p
74153 40p
74154 120p
74155 45p
74156 48p
74157 45p
74159 150p
74160 55p
74161 55p
74162 55p
74163 55p
74164 60p
74165 75p
74166 90p
74167 200p
74170 150p
74172 250p
74173 65p
74174 55p
74175 50p
74176 55p
74177 50p
74178 90p
74179 90p
74180 55p
74181 140p
74182 50p
74184 120p
74185A 120p
74190 60p
74191 60p
74192 60p
74193 60p
74194 50p
74195 50p
74196 46p
74197 48p
74198 120p
74199 120p
74221 80p
74251 60p
74259 100p
74265 55p
74273 120p
74276 120p
74278 100p
74279 55p
74283 50p
74285 160p
74286 160p
74290 75p
74293 90p
74298 120p
74351 150p
74365A 48p
74366A 48p
74367A 48p
74368A 48p
74376 100p
74390 90p
74393 150p
74490 120p

74LS SERIES

74LS00 20p
74LS01 20p
74LS02 20p
74LS03 20p
74LS04 20p
74LS05 20p
74LS08 20p
74LS09 20p
74LS10 20p
74LS11 20p
74LS12 20p
74LS13 25p
74LS14 36p
74LS15 20p
74LS20 20p
74LS21 20p
74LS22 20p
74LS26 20p
74LS27 20p
74LS28 20p
74LS30 20p
74LS32 25p
74LS33 20p
74LS37 20p
74LS38 20p
74LS40 20p
74LS42 36p
74LS47 60p
74LS48 60p
74LS51 20p
74LS54 20p
74LS55 20p
74LS73A 20p
74LS74A 30p
74LS75 30p
74LS76A 27p
74LS83A 46p
74LS85 60p
74LS86 25p
74LS90 32p
74LS91 60p
74LS92 40p
74LS93 32p
74LS95B 50p
74LS96 90p
74LS107 33p
74LS109 33p
74LS112 33p
74LS113 30p
74LS114 32p
74LS122 60p
74LS123 60p
74LS124/ 629 150p
74LS125 36p
74LS126 36p
74LS132 42p
74LS133 30p
74LS136 30p
74LS138 42p
74LS139 42p
74LS145 75p
74LS147 120p
74LS148 120p
74LS151 50p
74LS153 50p
74LS154 150p
74LS155 40p
74LS156 40p
74LS157 40p
74LS158 35p
74LS160A 50p
74LS161A 50p
74LS162A 45p
74LS163A 45p
74LS164 48p
74LS165A 60p
74LS166A 90p
74LS168 140p
74LS169 110p
74LS170 100p
74LS173A 90p
74LS174 45p
74LS175 45p
74LS181 120p
74LS183 120p
74LS190 60p
74LS191 60p
74LS192 60p
74LS193 60p
74LS194A 50p
74LS195A 50p
74LS196 60p
74LS197 54p
74LS221 80p
74LS240 70p
74LS241 70p
74LS242 60p
74LS243 60p
74LS244 70p
74LS245 140p
74LS247 70p
74LS248 70p
74LS249 70p
74LS251 45p
74LS253 45p
74LS256 200p
74LS257A 45p
74LS258A 45p
74LS259 80p
74LS260 35p
74LS261 80p
74LS266 25p
74LS273 75p
74LS275 175p
74LS279 35p
74LS280 180p
74LS283 50p
74LS290 55p
74LS292 900p
74LS293 50p
74LS295 70p
74LS297 900p
74LS298 65p
74LS299 200p
74LS321 240p
74LS323 200p
74LS324/ 624 150p
74LS348 140p
74LS352 70p
74LS353 70p
74LS356 175p
74LS363 180p
74LS364 180p
74LS365A 36p
74LS366A 36p
74LS367A 36p
74LS368A 36p
74LS373 75p
74LS374 75p
74LS375 60p
74LS377 90p
74LS378 85p
74LS379 92p
74LS390 60p
74LS393 90p
74LS395A 100p
74LS399 120p
74LS445 100p
74LS465 120p
74LS466 120p
74LS467 120p
74LS490 130p
74LS540 120p
74LS541 150p
74LS608 700p
74LS610 £19
74LS612 £19
74LS624 150p
74LS626 150p
74LS628 150p
74LS629 150p
74LS640 200p
74LS640-1 250p
74LS641 200p
74LS642-1 250p
74LS643 200p
74LS643-1 250p
74LS644 200p
74LS645 200p
74LS645-1 250p
74LS668 70p
74LS669 70p
74LS670 120p
74LS674 550p
74LS682 250p
74LS684 400p
74LS687 450p

74S SERIES

74S00 30p
74S02 30p
74S04 30p
74S05 60p
74S08 60p
74S10 40p
74S11 50p
74S20 40p
74S21 50p
74S22 50p
74S30 40p
74S32 70p
74S37 60p
74S51 75p
74S74 75p
74S85 300p
74S86 90p
74S112 90p
74S113 90p
74S114 90p
74S124 300p
74S132 110p
74S133 60p
74S138 110p
74S139 120p
74S140 60p
74S151 180p
74S153 180p
74S157 250p
74S158 195p
74S163 300p
74S174 250p
74S175 320p
74S188 150p
74S194 300p
74S195 300p
74S196 300p
74S200 450p
74S201 320p
74S225 650p
74S240 250p
74S241 300p
74S244 300p
74S251 250p
74S257 250p
74S258 250p
74S260 70p
74S261 300p
74S262 850p
74S283 300p
74S287 225p
74S288 150p
74S299 550p
74S373 400p
74S374 400p
74S387 250p
74S472 1150p
74S474 400p
74S475 825p
74S571 620p
74S573 900p

74C SERIES

74C00 20p
74C04 20p
74C08 20p
74C10 20p
74C14 30p
74C20 20p
74C32 25p
74C42 80p
74C48 120p
74C73 50p
74C74 45p
74C76 50p
74C83 120p
74C85 120p
74C86 30p
74C90 70p
74C93 70p
74C95 106p
74C107 70p
74C150 300p
74C151 100p
74C154 300p
74C157 150p
74C160 90p
74C161 90p
74C162 90p
74C163 90p
74C173 48p
74C174 90p
74C175 90p
74C192 100p
74C193 115p
74C194 120p
74C195 100p
74C221 150p
74C244 160p
74C245 180
74C373 160p
74C374 160p
74C902 70p
74C911 750p
74C912 700p
74C922 370p
74C923 450p
74C925 500p
74C926 500p
74C928 500p

74ALS Series

74ALS00 30p
74ALS02 30p
74ALS04 30p
74ALS08 30p
74ALS10 35p
74ALS20 35p
74ALS32 35p
74ALS74 50p
74ALS138 150p
74ALS139 150p
74ALS573 200p
74ALS574 400

4000 CMOS

4000 10p
4001 10p
4002 12p
4006 50p
4007 14p
4008 36p
4009 24p
4010 24p
4011 11p
4012 16p
4013 20p
4014 48p
4015 40p
4016 20p
4017 32p
4018 45p
4019 25p
4020 48p
4021 40p
4022 45p
4023 13p
4024 32p
4025 13p
4026 80p
4027 20p
4028 40p
4029 45p
4030 15p
4031 125p
4032 80p
4033 125p
4034 140p
4035 45p
4036 275p
4037 110p
4038 110p
4039 290p
4040 40p
4041 40p
4042 40p
4043 40p
4044 40p
4045 105p
4046 50p
4047 45p
4048 50p
4049 24p
4050 24p
4051 45p
4052 60p
4053 50p
4054 90p
4055 90p
4056 90p
4059 450p
4060 55p
4063 90p
4066 27p
4067 225p
4068 14p
4069 14p
4070 14p
4071 14p
4072 14p
4073 14p
4075 14p
4076 48p
4077 16p
4078 16p
4081 14p
4082 15p
4086 55p
4089 125p
4093 24p
4094 90p
4095 75p
4096 70p
4097 290p
4098 90p
4099 100p
4500 575p
4502 60p
4503 45p
4504 75p
4505 400p
4506 35p
4507 35p
4508 130p
4510 45p
4511 45p
4512 48p
4514 120p
4515 110p
4516 55p
4518 40p
4520 50p
4521 90p
4522 120p
4526 60p
4527 60p
4528 50p
4532 70p
4534 400p
4536 270p
4538 90p
4539 70p
4543 75p
4553 245p
4555 35p
4556 35p
4557 300p
4560 120p
4566 160p
4568 250p
4569 170p
4572 30p
4583 90p
4584 40p
4585 75p
40014 40p
40085 90p
40097 45p
40102 140p
40103 170p
40105 110p
40106 40p
40109 100p
40110 275p
40163 60p
40174 50p
40175 75p
40193 75p
40244 160p
40245 180p
40257 160p
40373 160p
40374 160p
14411 700p
14412 800p
14416 380p
14419 280p
14490 350p
14495 300p
14500 700p
14599 290p

COUNTERS

74C925 £4
74C926 £5
74C928 £6
72168 £22
ZN1040 670p

DIL SWITCHES

4-way 90p
8-way 120p
6-way £105p
10-way 150p

LINEAR ICs

AD7581 £14
ADC0808 990p
AN103 200p
AY1-5050 99p
AY3-1270 750p
AY3-1350 350p
AY3-8910 350p
AY3-8912 500p
AY5-3600 600p
AY5-4007D 520p
CA3028A 120p
CA3019 80p
CA3046 70p
CA3048 220p
CA3059 285p
CA3060 350p
CA3080E 70p
CA3086 48p
CA3089E 200p
CA3090AQ 375p
CA3130E 90p
CA3130T 110p
CA3140E 40p
CA3140T 90p
CA3160E 100p
CA3161E 150p
CA3162E 450p
CA3189E 300p
CA3240E 110p
CA3280G 200p
D7002 390p
DAC0800 £2
DAC0808 £2
DG308 300p
HA1366 190p
HA1388 250p
ICL7106 700p
ICL7650 400p
ICL7660 250p
ICL7611 95p
ICL8038 300p
ICM7217 750p
ICM7555 80p
ICM7556 140p
LC7120 300p
LC7130 325p
LC7137 270p
LF347 150p
LF351 48p
LF353 95p
LF356P 95p
LF357 110p
LF13331 350p
LM10C 325p
LM301A 25p
LM307 50p
LM308N 75p
LM310 120p
LM311 70p
LM318 150p
LM319 215p
LM319N 160p
LM324 30p
LM334Z 90p
LM335Z 140p
LM339 40p
LM348 65p
LM358P 60p
LM377 175p
LM380 75p
LM381AN 180p
LM382 120p
LM386 90p
LM387 120p
LM389 95p
LM391 150p
LM392N 60p
LM393 100p
LM394CH 300p
LM709 36p
LM710 50p
LM711 70p
LM725 300p
LM733 60p
LM741 18p
LM747 70p
LM748 35p
LM1011 480p
LM1014 150p
LM1801 300p
LM1830 250p
LM1871 300p
LM1872 300p
LM1886 £5
LM1889 350p
LM2917 200p
LM3302 75p
LM3900 50p
LM3909 85p
LM3911 125p
LM3914 200p
LM3915 200p
LM3916 225p
LM13600 110p
M51513L 230p
M51516L 500p
MB3712 200p
MB3730 400p
MC1310P 150p
MC1413 75p
MC1458 36p
MC1493 100p
MC1495L 350p
MC1496 70p
MC3340P 120p
MC3401 50p
MC3403 65p
MF10CN 320p
MK50240 900p
MK50398 700p
ML920 800p
MM57160 620p
MN6221A 600p
NE531 140p
NE544 150p
NE555 16p
NE556 45p
NE564 420p
NE565 120p
NE566 155p
NE567 140p
NE570 410p
NE571 400p
NE592 60p
NE5532 130p
NE5533 140p
NE5534P 110p
NE5534AP 125p
PLL02A 500p
RC4136 60p
S566B 225p
SAA1900 £16
SAD1024A 1150p
SFF96364 800p
SN76488 450p
SN76489 480p
SN76495 400p
SP0256AL £10
TA7120 150p
TA7130 160p
TA7204 150p
TA7205 90p
TA7222 150p
TA7310 150p
TBA231 120p
TBA800 80p
TBA810 100p
TBA820 80p
TBA950 225p
TC9109 750p
TCA210 250p
TCA220 350p
TCA270 350p
TCA940 175p
TCA965 120p
TDA1004A £3
TDA1008 320p
TDA1010 200p
TDA1022 500p
TDA1024 120p
TDA1170 300p
TDA2002 325p
TDA2003 325p
TDA2006 350p
TDA2020 320p
TDA7000 350p
TL064 95p
TL071/81 25p
TL072/82 45p
TL074 100p
TL083 75p
TL084 90p
TL094 200p
TL170 50p
TL430C 70p
UA1003-3 935p
UA2240 120p
UAA170 170p
ULN2003A 75p
ULN2004 75p
ULN2068 290p
ULN2802 200p
ULN2803 150p
ULN2804 150p
UPC575 275p
UPC592H 200p
UPC1156H 275p
UPC1185H £5
XR210 400p
XR2206 400p
XR2211 575p
XR2240 120p
ZN414 80p
ZN419C 190p
ZN423E 130p
ZN424E 130p
ZN425E 340p
ZN426E 300p
ZN427E 590p
ZN428E 450p
ZN429E 210p
ZN450E 790p
ZN459 600p
ZN1034E 200p
ZN1040E 670p
ZNA134 £23
ZNA234 850p

VOLTAGE REGULATORS

FIXED PLASTIC

1A	+ve		-ve	
5V	7805	40p	7905	45p
6V	7806	40p	7906	45p
8V	7808	40p	7908	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p	7924	45p
5V 100mA	78L05	30p	79L05	45p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
12V 100mA	78L12	30p	79L12	50p
15V 100mA	78L15	30p	79L15	50p

TRANSISTORS

AD161/2 45p
BC107/8 13p
BC109C 14p
BC169C 12p
BC172 12p
BC177/8 17p
BC179 18p
BC182/3 10p
BC184 11p
BC187 30p
BC212/3 11p
BC214 12p
BC237 15p
BC327 16p
BC337 16p
BC338 16p
BC461 25p
BC477/8 30p
BC516/7 40p
BC547B 14p
BC548C 12p
BC549C 16p
BC557B 14p
BC559C 16p
BCY70 18p
BCY71 22p
BD131 75p
BD132 80p
BD135/6 40p
BD139 40p
BD140 40p
BD189 60p
BD232 60p
BD233 75p
BD235 85p
BD241 60p
BD242 60p
BD379 60p
BD380 60p
BD677 40p
BF244B 35p
BF256B 50p
BF257/8 32p
BF337 30p
BFR39 25p
BFR40/1 25p
BFR79 25p
BFR80/1 25p
BFR96 180p
BFX29 40p
BFX30 27p
BFX84/5 40p
BFX86/7 27p
BFX88 27p
BFX89 180p
BFY50 24p
BFY51/2 24p
BFY56 33p
BFY90 80p
BRY39 45p
BSX19/20 24p
BU104 225p
BU105 190p
BU108 250p
BU109 225p
BU126 150p
BU180A 120p
BU205 200p
BU208 200p
BU406 145p
BUX80 600p
BUY69C 350p
E310 50p
MJ802 400p
MJ2501 225p
MJ2955 90p
MJ3001 225p
MJ4502 400p
MJE340 60p
MJE2955 100p
MJE3055 70p
MPF102 40p
MPF103/4 30p
MPF105 30p
MPSA06 30p
MPSA12 50p
MPSA13 50p
MPSA20 50p
MPSA42 50p
MPSA43 50p
MPSA56 32p
MPSA70 50p
MPSA93 40p
MPSU06 63p
MPSU07 60p
MPSU45 90p
MPSU65 78p
TIP29A 35p
TIP29C 40p
TIP30A 35p
TIP30C 40p
TIP31A 40p
TIP31C 45p
TIP32A 45p
TIP32C 40p
TIP33A 70p
TIP33C 80p
TIP34A 90p
TIP34C 120p
TIP35A 120p
TIP35C 140p
TIP36A 140p
TIP36C 150p
TIP41A 50p
TIP41C 55p
TIP42A 60p
TIP42C 65p
TIP54 160p
TIP120 75p
TIP121 75p
TIP122 80p
TIP142 120p
TIP147 120p
TIP2955 78p
TIP4055 70p
TIS93 30p
VN10KM 50p
VN66AF 90p
VN88AF £1
ZTX108 12p
ZTX300 13p
ZTX452 45p
ZTX500 15p
ZTX502 16p
ZTX504 18p
ZTX552 55p
ZTX652 60p
ZTX752 70p
2N697 25p
2N698 45p
2N706A 30p
2N708 30p
2N918 45p
2N930 18p
2N1131/2 36p
2N1613 25p
2N1711 25p
2N2102 70p
2N2160 350p
2N2219A 25p
2N2222A 25p
2N2369A 17p
2N2484 25p
2N2646 40p
2N2904/5 25p
2N2906A 25p
2N2907A 25p
2N2926 9p
2N3053 25p
2N3054 55p
2N3055 35p
2N3442 140p
2N3553 240p
2N3584 250p
2N3643/4 48p
2N3702/3 10p
2N3704/5 10p
2N3706/7 10p
2N3708 10p
2N3773 200p
2N3819 20p
2N3823 30p
2N3866 90p
2N3902 700p
2N3904 15p
2N3906 16p
2N4037 65p
2N4056 65p
2N4123/4 27p
2N4125/6 27p
2N4401/3 25p
2N4427 90p
2N4871 50p
2N5087 27p
2N5089 27p
2N5172 27p
2N5191 90p
2N5245 40p
2N5401 60p
2N5459 30p
2N5460 60p
2N5485 36p
2N5875 250p
2N6027 30p
2N6052 300p
2N6059 325p
2N6107 65p
2N6247 190p
2N6254 130p
2N6290 65p
2SC1306 100p
2SC1307 150p
2SC1957 90p
2SC1969 150p
2SC2028 80p
2SC2029 200p
2SC2078 160p
2SC2335 200p
2SC2612 200p
3N128 120p
3N140 120p
3N141 110p
3N201 110p
3N204 200p
40290 250p
40361/2 75p
40408 90p
40409 100p
40410 100p
40594 120p
40595 120p
40673 75p
40871/2 100p

COMPUTER COMPONENTS

CPUs

1802CE 650p
2650A £12
6502 350p
6502A 500p
6800 225p
6802 250p
6809 650p
68705P35 £25
68B09E £16
8035 350p
8039 300p
8080A 250p
8085A 350p
8086 £22
8088 £18
8748 £18
INS8060 £11
TMS1601 £12
TMS9980 £20
TMS9995 £12
Z8 £24
Z80A 300p
Z80AS10/0/1 £9
Z80AS10/2/9 £9
Z80B £9

SUPPORT DEVICES

2651 £12
3242 800p
3245 450p
6520 280p
6522 310p
6522A 550p
6532 550p
6551 650p
6821 100p
68B21 220p
6829 £12.50
6840 375p
68B40 600p
6850 110p
68B50 220p
6852 250p
6854 700p
68B54 800p
6875 570p
8154 950p
8155 350p
8156 350p
8205 225p
8212 110p
8216 100p
8224 110p
8226 250p
8228 270p
8243 280p
8250 850p
8251 250p
8253 390p
8255 250p
8256 £36
8257 400p
8259 400p
8271 £36
8279 440p
8284 350p
8288 £11
8755 £16
9901 £10
9902 £3
TMS4500 £14
TMS5220 £12
TMS9909 £9
TMS9911 £16
Z80P10 250p
Z80AP10 280p
Z80CTC 250p
Z80ACTC 280p
Z80ADART 700p
Z80ADMA £9
Z80SIO/1/2 £9

MEMORIES

2102-3L 120p
2111A 300p
2112-A 300p
2114-2L 100p
2147 450p
2764-25 500p
27128-30 £16
27128-25 £20
4027-3 300p
4116-15 120p
4116-20 90p
4118-3 450p
4164-2 400p
4164-15 450p
4416-15 500p
4532-20 250p
4816AP-3 270p
5101 300p
5516 750p
6116-3 420p
6116LP-3 550p
6514-45 200p
6810 120p
74S189 150p
74S201 350p
74S289 150p
93415 600p
93425 600p
93L422 950p

ROMs/PROMs

74S188 140p
74S287 200p
74S288 140p
74S387 225p
74S473 850p
74S474 650p

EPROMs

2532 350p
2532-30 700p
2564 £6
2708 300p
2716 250p
2732 350p
2732A-35 450p
2764-25 £4.50
27128-25 £22

CRT CONTROLLER

CRT6545 900p
CRT5027 £18
CRT5037 £18
EF9365 £36
EF9366 £36
MC6845 650p
MC6845SP £12
MC6847 650p
SFF96364 £8
TMS9918 £60
TMS9927 £14
TMS9928 £20
TMS9929 £16

INTERFACE ICs

AD558CJ 775p
AD561J £20
AM25S10 350p
AM25LS2521 £2
AM26LS31 125p
AM26LS32 125p
D7002 390p
DAC80 £28
DM8131 275p
DP8304 250p
DS3691 300p
DS8830 150p
DS8831 140p
DS8832 250p
DS8833 225p
DS8836 150p
DS8838 225p
DS8880 170p
LF13201 450p
MC1488 55p
MC1489 55p
MC3418 950p
MC3446 250p
MC3459 450p
MC3470 650p
MC3480 850p
MC3486 500p
MC3487 300p
MC4024 325p
MC4044 325p
MC14411 675p
MC14412 750p
75107 90p
75110/12 160p
75114/15 160p
75121/22 140p
75150P 120p
75154 140p
75159 220p
75365 150p
75451/2 72p
75453/4 72p
75491/2 65p
8T26 120p
8T28 120p
8T95/96 90p
BT97/98 90p
81LS95/96 120p
81LS97/98 120p
88LS120 350p
9602 220p
9637AP 160p
ZN425E-8 350p
ZN426E-8 350p
ZN427E £6
ZN428E-8 450p

DISC CONTROL ICs

8271 £36
8272 £20
FD1771 £20
FD1791 £22
FD1793 £23
FD1795 £28
FD1797 £28
FD2793 £42
FD2797 £42
WD1691 £15
WD2143 550p

CHARACTER GENERATORS

RO3-2513 U.C. 750p L.C. 700p
DM86564 £12
MC66760 750p
SN74S262AN £10

KEYBOARD ENCODER

AY5-2376 950p
74C922 500p
74C923N 500p

BAUD RATE GENERATORS

MC14411 700p
COM8116 800p
4702B 750p

UARTs

AY-3-1015P 300p
AY-5-1013P 300p
COM8017 300p
IM6402 360p
TR1602 300p

ZIF SKTS

(TEXTOOL)

24 pin	575p
28 pin	800p
40 pin	975p

MODULATORS

6MHz UHF 375p
8MHz UHF 450p

CRYSTALS

32 768KHz 100p
100KHz 250p
200KHz 280p

Freq in MHz

1.0	290p
1.008	275p
1.8432	210p
2.00	225p
2.45760	210p
2.5	250p
2.662	250p
3.276	150p
3.5795	100p
3.686	300p
4.00	150p
4.194	200p
4.43	110p
4.608	250p
4.915	250p
5.0	175p
5.068	£2
6.0	150p
6.144	150p
7.0	150p
7.168	175p
8.00	175p
8.86	175p
10.00	175p
10.5	250p
10.7	150p
12.00	150p
14.318	175p
14.756	250p
15.00	200p
16.00	200p
17.7	200p
18.00	200p
18.432	150p
19.968	150p
20.00	200p
24.00	£2
26.690	150p
38.6667	175p
48.0	175p
55.5	400p
116	300p
145.80	250p

REAL TIME CLOCK

MK3805 £TBA
MM58174 700p
MSM5832 350p

TELETEXT DECODER

SAA5020 600p
SAA5030 700p
SAA5041 £16
SAA5050 900p

LOW PROFILE SOCKETS BY TI

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

WIRE WRAP SOCKETS BY TI

8 pin	30p	18 pin	50p	24 pin	75p
14 pin	42p	20 pin	66p	28 pin	100p
16 pin	45p	22 pin	75p	40 pin	130p

DIODES

BY127 12p
BYX36300 20p
OA47 8p
OA90/91 9p
OA95 9p
OA200 9p
OA202 10p
1N914 4p
1N916 7p
1N4148 4p
1N4001/2 5p
1N4003/4 6p
1N4005 6p
1N4006/7 7p
1N5401/2 12p
1N5403/4 14p
1N5404/5 14p
1N5404/7 19p
IS920 9p

BRIDGE RECTIFIERS

1A	50V	19p
1A	100V	20p
1A	400V	25p
1A	600V	30p
2A	50V	30p
2A	100V	35p
2A	400V	45p
3A	200V	60p
3A	600V	72p
4A	100V	95p
4A	400V	100p
6A	50V	80p
6A	100V	100p
6A	400V	120p
10A	400V	200p
25A	400V	400p

TRIACS PLASTIC

3A 400V 60p
6A 400V 70p
6A 500V 88p
8A 400V 75p
8A 500V 95p
12A 400V 85p
12A 500V 105p
16A 400V 110p
16A 500V 130p
T2800D 130p
TIC 206D 60p
TIC 226D 75p
TIC 246D 110p

THYRISTORS

3A 400V 45p
8A 600V 180p
12A 400V 160p
16A 100V 180p
16A 400V 180p
C106D 45p
MCR101 36p
2N3525 130p
2N4444 180p
2N5060 30p
2N5061 32p
2N5064 35p

PCB MOUNTING RELAYS

6 or 12V DC Coil SPDT 2A 24V DC 160p
6 or 12V DC Coil DPDT 5A 24V DC 240V AC 200p
6 or 12V DC Coil SPDT 10A 24V DC 240V AC 225p

ZENERS

2.7V-33V 400mW 9p
1W 15p

WW-5

TECHNOMATIC LTD

MAIL ORDERS TO: 17 BURNLEY ROAD, LONDON NW10 1ED
SHOPS AT: 17 BURNLEY ROAD, LONDON NW10
(Tel: 01-452 1500, 01-450 6597. Telex: 922800)
305 EDGWARE ROAD, LONDON W2

PLEASE ADD 40p p&p & 15% VAT
(Export: no VAT, p&p at Cost)

Orders from Government Depts. & Colleges etc. welcome.

Detailed Price List on request.
Stock items are normally by return of post.

www.americanradiohistory.com

28 RANGES, EACH WITH FULL OVERLOAD PROTECTION

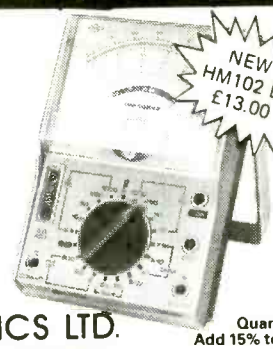
Accurate Digital Multimeters at Exceptional Prices

6010 .5% Accuracy £29.95

7030 .1% Accuracy £35.95

6010 & 7030 MODELS SPECIFICATION

- 10 amp AC/DC
- Battery: single 9V drycell. Life: 200 hrs
- Dimensions: 170 × 89 × 38mm.
- Weight: 400g inc. battery.
- Mode Select: Push Button
- AC DC Current: 200μA to 10A
- AC Voltage: 200mV to 750V
- DC Voltage: 200mV to 1000V
- Resistance: 200Ω to 20MΩ
- Input Impedance: 10MΩ
- Display: 3½ Digit 13mm LCD
- O/load Protection: All ranges



NEW HM102 BZ £13.00

ANALOGUE HM182BZ WITH CONTINUITY BUZZER AND BATTERY SCALE

- DC Voltage: 0-25, 1, 2.5, 10, 25, 100, 250, 1000 volts 20,000 ohms/volt.
- AC Voltage: 0-10, 25, 100, 250, 1000 volts 10,000 ohms/volt.
- Decibels: -20 to +22dB
- DC Current: 0-50, 500μA, 0-5, 50, 500mA
- Ohmmeter: 0-6 Megohms in 4 ranges. 30 ohms Centre Scale.
- Power Supply: One 1.5V size 'A' battery (incl)
- Size & Weight: 135 × 91 × 39mm, 280gr.

OTHER features: Auto polarity, auto zero, battery low indicator, ABS plastic case with tilt stand, battery and test leads included, optional carrying case.

ARMON ELECTRONICS LTD.
Cottrell House, 53-63 Wembley Hill Road
Wembley, Middlesex HA9 8BH, England
Telephone: 01-902 4321 (3 lines). TELEX No. 923985

Quantity discount for trade on application
Add 15% to your order for V.A.T. P&P is free of charge
Payment by cheque with order
or accepted

WW – 023 FOR FURTHER DETAILS

STEREO MICROPHONE AMPLIFIER

- 50 or 200 Ohm balanced microphones to balanced lines
- Variety of low frequency characteristics for improving the clarity of recordings
- Inputs filtered against radio interference
- Complete boxed unit or double mumetal screened amplifier module alone

Surrey Electronics Ltd., The Forge, Lucks Green, Cranleigh, Surrey GU6 7BG England. Tel: 0483 275997

CLEF ELECTRONIC MUSIC

PIANOS

SPECIALISTS SINCE 1972
DOMESTIC OR STAGE
SIX OR 7¼ OCTAVES
KITS OR MANUFACTURED

The most advanced form of touch-sensitive action simulating piano key inertia by patented technique.

Four mixable voices for serious tone variation plus electronic chorus and flanger effects.

Component Kits include Keyboard.

Full Kits further contain: Cabinets, Harness, Power Amp and Speaker.

DOMESTIC PRICES

£	SIX	7¼
Comp	234	266
Full	398	442
MFD	620	695

Kit £314
Mfd £469

VOCAL & INSTRUMENTAL SOLOISTS!

BAND-BOX
An Electronic Backing TRIO. Drums, Bass & Chord Instrument. User Programmable for 50-100 scores, using microprocessor.

MASTER RHYTHM
User Programmable DRUM MACHINE. Twenty-four patterns. Eight parallel tracks. Twelve instruments sequence operation.

Kit £79
Built £129

Write or Phone for full details of our range of high quality Kit and manufactured Electronic Musical Instruments. Prices include V.A.T., Carr., & Ins. and we operate Telephone BARCLAYCARD/ACCESS.
Competitive EXPORT Quotations given.

CLEF PRODUCTS (ELECTRONICS) LIMITED
Dept. W, 44a Bramhall Lane South, Bramhall, Stockport, Cheshire SK7 1AH
061-439 3297

WW – 056 FOR FURTHER DETAILS

Greatech Electronics LTD

DISPLAY & COMMUNICATION PRODUCTS

Hay Lane,
Braintree,
Essex CM7 6ST

Telephone (0376) 327111
Telex 987911
24-Hour Ansaphone Service

R.F. POWER TRANSISTORS
Many other types available

2N3375	5.85	SD 1005	6.48	MRF 221	12.05
2N3553	1.50	SD 1006	1.80	MRF 231	9.36
2N3733	3.20	SD 1012FL	7.50	MRF 234	13.80
2N3866	1.00	SD 1013	7.50	MRF 237	2.75
2N3926	9.85	SD 1088	23.00	MRF 238	12.60
2N3927	11.02	SD 1089	25.64	MRF 239	15.00
2N4416	0.75	SD 1098	32.82	MRF 240	18.55
2N4427	1.00	SD 1127	2.60	MRF 243	28.08
2N4440	6.50	SD 1135	8.42	MRF 245	30.10
2N5016	6.72	SD 1136	11.80	MRF 247	34.00
2N5090	16.80	SD 1143	8.50	MRF 260	5.00
2N5109	2.01	SD 1219	11.40	MRF 261	7.00
2N5179	0.86	SD 1229FL	7.80	MRF 262	10.40
2N5485	0.62	SD 1272	10.20	MRF 264	11.00
2N5486	0.66	SD 1272FL	10.20	MRF 314	25.06
2N5589	4.70	SD 1407	22.50	MRF 401	10.84
2N5590	6.85	SD 1410	19.68	MRF 406	11.83
2N5591	8.90	SD 1412	27.18	MRF 421	31.57
2N5635	5.20	SD 1416	30.00	MRF 422	35.52
2N5636	9.70	SD 1418	26.22	MRF 449A	14.00
2N5637	11.25	SD 1428	23.00	MRF 450A	11.40
2N5641	5.35	SD 1429	13.98	MRF 453	13.30
2N5642	7.90	SD 1444	3.00	MRF 454A	16.80
2N5643	13.00	SD 1488	26.25	MRF 455	13.80
2N5913	2.10	2SC730	3.84	MRF 460	15.78
2N5944	6.90	2SC1165	5.88	MRF 464	31.57
2N5945	8.95	2SC1177	16.14	MRF 472	2.50
2N5946	11.40	2SC1306	1.44	MRF 475	2.40
2N6080	5.10	2SC1307	2.34	MRF 476	1.71
2N6081	6.75	2SC1678	1.44	MRF 477	10.70
2N6082	8.45	2SC1946A	18.54	MRF 515	2.70
2N6083	8.75	2SC1947	9.24	MRF 604	1.60
2N6084	11.70	2SC1970	2.76	MRF 607	2.20
2N6094	5.00	2SC1971	7.50	MRF 629	4.10
2N6095	6.90	2SC1972	10.32	MRF 646	26.24
2N6096	8.40	2SC2237	15.00	MRF 648	35.14
2N6097	13.30	2SC2538	1.62	MRF 901	2.58

NEW VALVES
National, Varian, Mullard, RCA, ITT...

E80CC	15.00	6AU6A	2.30
E80F	13.30	6AU5GA	4.25
E88CC	4.50	6AW8A	2.85
E180F	8.00	6B8	3.10
EC91	8.65	6BA8A	3.40
ECC81	1.19	6BH6	2.55
ECC82	1.19	6BQ7A	3.45
ECC83	1.19	6BR8A	3.50
ECC88	2.30	6B26	2.50
ECC91	3.75	6CB6A	2.30
ECH81	2.50	6CD6GA	4.65
EF86	1.35	6CL6	3.40
EL34	2.68	6CW4	6.85
EL84	1.00	6DK6	2.65
KT77	6.80	6DQ5	5.50
PC92	4.00	6DQ6B	4.00
PCF802	1.60	6EA8	2.50
PCL805	1.00	6GK6	2.46
PL509	4.75	6J4	4.20
PL519	4.75	6J5	4.30
PY500A	2.98	6J6A	4.90
QQVO2-6		6JB6A	4.05
/6939	15.75	6JS6C	5.00
QQVO3-10		6K6GT	2.75
/6360	9.50	6KD6	5.60
QQVO3-20A		6LQ6	6.00
/6252	63.00	65N7GTB	2.75
QQVO6-40A		6080	11.00
/5894	45.00	6146A	7.70
QVO3-12		6146B	7.70
/5763	5.80	6159B	18.00
UCL 82	1.60	6201	6.30
2D21	2.85	6360	6.00
3B28	14.95	6550A	6.70
4CX250B	37.10	6688	9.80
4CX350A	69.50	6689	12.24
5U4GB	2.50	6883B	7.70
5670	3.40	6973	3.85
5726	2.40	7360	9.50
5763	4.05	7551	5.90
5814A	3.50	7558	9.50
5842	11.20	7591A	3.80
5965	3.25	7868	3.95
6AH6	4.75	811A	14.75
8AK5	3.55	812A	18.55
6AK6	2.00	813A	60.00
6AN5	4.40	866A	15.00
6AN8A	3.20	872A	15.65
6AQ5A	2.15	8298A	4.90
6AS6	5.10	8417	5.80
6ASTG	6.45	931A	18.20
6AT6	1.35	12AY7	3.75
6AU5GT	4.50	12BY7A	2.60

Normally stock items are shipped by return post.
We can supply nearly **ANY TYPE OF VALVE or RF POWER TRANSISTOR** – ring for quotation.

TERMS: Cash, Postal Order or Cheque with order

CREDIT: Accounts available subject to approved references

POSTAGE: Add 60p to order

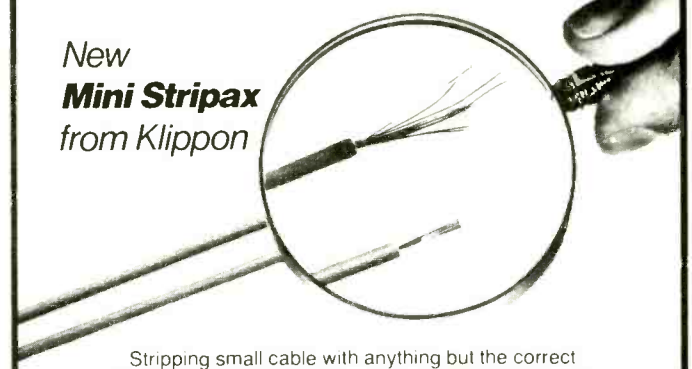
VAT: All prices are excluding VAT, please add 15% to order

GUARANTEE: All goods brand new and to specification

WW – 069 FOR FURTHER DETAILS

The smaller the cable... the greater the hazard.

New
Mini Stripax
from Klippon



Stripping small cable with anything but the correct tool can cause unseen damage, and a damaged conductor can be a hidden hazard.

The new Mini Stripax with built-in cutter, provides a perfect finish with one simple stripping action. Cuts and strips cables from 0.08mm² to 1.0mm².

So don't risk your reputation on chance. Get the right tool for the job.

Klippon

Klippon Electricals Ltd. Power Station Road, Sheerness, Kent ME12 3AB
Telephone (0795) 663322 Telex 96176

WW – 067 FOR FURTHER DETAILS

www.americanradiohistory.com

LOGIC ANALYSERS

Thandar's comprehensive range of professional specification instruments now includes 8 and 16 channel logic analysers to expand your test capabilities. Both analysers feature DC to 20MHz sampling rates, synchronous or asynchronous clocking and 15ns glitch capture in latch mode. There is also a powerful compound trigger delay by event and/or clock (two level triggering on TA2160), selectable trigger position, variable trigger filter and clock qualifier and arm facilities. All inputs are high impedance with TTL or variable threshold. Both have a composite video output to drive an external display or video printer and offer disassembler options for common microprocessors. Accessories are available for serial data capture and hard copy record printout.

TA2080 (8 CHANNEL) Full system information always shown in display; 8 bit data and reference memories, both 252 bytes deep; 23 bit triggering (8 data bits, 15 trigger bits); Timing display shows all 252 bytes of the 8 data channels in timing diagram format with x2, x4, x8 expansions available; State display shows 24 sequential bytes in either binary plus ASCII or hex plus octal plus ASCII; Automatic or manual compare between recording and reference memories for equality or inequality.

TA2160 (16 CHANNEL) 16 bit data and reference memories, 252 samples deep; Both data and reference memories configurable as 16 bit x 252 samples, 8 bit x 504 samples, or 2 x 8 bit x 252 samples; 34 bit triggering (16 data, 12 trigger and 6 qualifiers); Independent clocks and clock qualifiers in 2 x 8 bit modes; Sample or latch assignable on a per pod basis; Timing display shows 252 bytes of any 8 channels in timing diagram format with x2, x4, x8 expansions available; State display shows 16 sequential store locations of any 4 memories in 4 columns; each memory can be displayed in either binary, hex, octal, decimal, ASCII, or EBCDIC; Automatic or manual compare between any part of any two memories for equality or inequality; TTL or variable threshold assignable on a per pod basis; RS232 interface permits dumping and loading of reference memories and all system parameters.

Send for our complete catalogue and price list.
Thandar Electronics Ltd, London Road, St. Ives, Huntingdon, Cambridgeshire, PE17 4HJ.
Telephone (0480) 64646. Telex 32250.

thandar
ELECTRONICS LIMITED THE LOGICAL CHOICE

TH11

WW – 055 FOR FURTHER DETAILS

HART

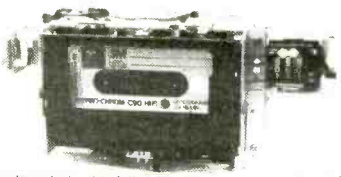
LINSLEY-HOOD 300 SERIES AMPLIFIERS

30 Watt Complete Kit	£65
35 Watt Complete Kit. MosFet O/P	£79.50
45 Watt Complete Kit. MosFet O/P	£83.50
Reprints of 30 Watt Article from 'Hi-Fi News'	50p
Reprints of MosFet Postscript to above	30p

'P.W. WINTON' TUNER AND AMPLIFIER

Tuner. Complete Kit	£163
Amplifier. Complete Kit	£98
Amplifier Reprint	£1.25

SOLENOID CONTROLLED HI FI/DIGITAL CASSETTE MECHANISM



Front loading deck with full solenoid control of all functions including optional read in fast wind modes. 12 volt operation. Fitted 3-digit memory counter and Hall IC Motion Sensor. Standard erase and stereo R/P Heads. Cheapest price ever for all these features. Only **£38.90** plus VAT. Full technical specification included.

LINSLEY-HOOD 100 WATT POWER AMPLIFIER

Our complete kit for this brilliant new design is the same size as our Linsley-Hood Cassette Recorder 2. Kit includes all parts for two power amplifiers with large heatsink area, huge power supply and speaker protection circuit. Total cost of all parts is **£114.46** but our special introductory price for all parts bought together is only **£105.50**.

THIS MONTH'S SPECIAL OFFERS

DOLBY 'B' NOISE REDUCTION IC LM1011
Marvellous opportunity for home experimenters, build your own noise reduction system. Supplied complete with circuit showing typical application. **Absolute knockout price only £3.50 for two inc. VAT and post.**

COMPLETE STEREO CASSETTE DECK
Brand new high quality top-loading Cassette Deck complete with Record/Play electronics. Supplied with connection data and circuit diagram. Automatic chrome/ferric switching. Only needs 9v DC supply. **Total price only £18.34 inc. VAT and post.**

COMPLETE STEREO TUNER MODULE
Three band LW/MW/FM Stereo Tuner fully assembled on PCB 165 x 85 mm. Supplied with Ferrite rod aerial and band switch fully wired. Facility provided to drive tuning meter and stereo LED. Only needs 12v DC supply. FM sensitivity. 2.5uV. **Price only £7.99 inc. VAT and post.**

ALPS FF317U FM FRONT END
Beautiful, precision made High Quality variable capacitor tuned FM Front End with Dual-gate MosFet. The tuning capacitor also has 2-AM Gangs and built-in 3:1 reduction gear.
Covers full FM range of 87 to 109 MHz. Supply needed is 12v at only 30mA Max. Inputs are provided for AGC and AFC signals. These have recently been on special offer from another supplier at £4 plus VAT. OUR PRICE IS ONLY £3.99 INCLUDING VAT AND POSTAGE! Circuit if required 35p.

HIGH QUALITY REPLACEMENT CASSETTE HEADS

Do your tapes lack treble? A worn head could be the problem. Fitting one of our replacement heads could restore performance to better than new! Standard mountings make fitting easy and our TC1 Test Cassette helps you set the azimuth spot-on. We are the actual importers which means you get the benefit of lower prices for prime parts. Compare us with other suppliers and see! The following is a list of our most popular heads, all are suitable for use or Dolby machines and are ex-stock.

HC20 Permalloy Stereo Head. This is the standard head fitted as original equipment on most decks	£4.25
HM90 High Beta Permalloy Head. A hard-wearing, higher performance head with metal capability	£8.20
HS16 Sendust Alloy Super Head. The best head we can find. Longer life than Permalloy, higher output than Ferrite, fantastic frequency response	£8.20
HQ551 4-Track Head for auto-reverse or quadrophonic use. Full specification record and playback head	£7.40

Please consult our list for technical data on these and other Special Purpose Heads.

HART TRIPLE-PURPOSE TEST CASSETTE TC1

One inexpensive test cassette enables you to set up VU level, head azimuth and tape speed. Invaluable when fitting new heads. Only **£3.80** plus VAT and 50p postage.

Tape Head De-magnetiser. Handy size mains operated unit prevents build up of residual head magnetisation causing noise on playback **£3.68**

Full details of the entire range of HART products is contained in our illustrated lists.
Ask for your FREE copy NOW.
Enquiries for lists are also welcome from overseas but please let us have three IRCs to cover the cost of surface post or 5 IRCs for airmail.
In a hurry? A telephone order with credit card number placed before 3 p.m. will be despatched THAT DAY!
Please add part cost of post, packing and insurance as follows:

INLAND
Orders up to £10 – 50p
Orders £10 to £49 – £1
Orders over £50 – £1.50

OVERSEAS
Postage at cost plus £2 documentation and handling

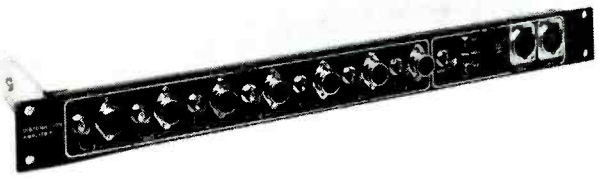
Please Note: New Phone Number: **(0691) 652894**
Personal callers are always very welcome but please note that we are closed all day Saturday

PLEASE ADD VAT TO ALL PRICES

HART
HART ELECTRONIC KITS LTD
PENYLAN MILL
OSWESTRY, SHROPSHIRE
SY10 9AF

www.americanradiohistory.com

VIDEO DISTRIBUTION



Dwight Cavendish now have available a 7 channel Video Distribution Amplifier plus twin channel sound (stereo) for £189.

This rugged, high performance device comes complete in a 1U high 19" rack mount unit. Many of the latest design features are incorporated including vertical interval switching, switchable bal-balun input options on audio, on-board switchable equalisation etc.

For further information contact Dwight Cavendish Sales

Dwight Cavendish

Paxton Hall, Gt. North Road, Little Paxton, Huntingdon, Cambridgeshire, PE19 4EL

Telephone: 0480 215778 215753

WW – 064 FOR FURTHER DETAILS

MASTERING MICROPROCESSOR BEGIN WITH LS6802

LS6802 is a complete learning system to master microprocessor hardware and software. It is based on the 6802 CPU, an improved version of the renowned 6800 and is a good starting point to master the varieties of 6800 family microprocessors so widely used in industry.

Its features include:
2K monitor program with 20 editing, debugging functions; 2K RAM: spare socket for 2K RAM or 4K EPROM; built-in breadboarding system for hardware experiments; speaker; cassette tape interface; 16 programmable I/O lines (6821 PIA); 3 user keys; the full capabilities of 6802 CPU and an AC/DC adaptor to power the LS. An ideal tool for learning, teaching, experimenting and prototyping at only £109.00.

Distributors Invited

Binary System, Maxwell Road, P.O. Box 1583
Singapore 9031, Republic of Singapore

Send me ..... unit(s) of LS6802 at £109 each. Which will be paid for on receipt of invoice by International Money Order/ Bankdraft/Visa/Master Card/American Express.
There will be a delivery period of six weeks.

Name .....

Signature .....

Address .....

.....

.....

.....

PM COMPONENTS LTD

VALVE & COMPONENTS SPECIALISTS

INTEGRATED CIRCUITS

AN124	2.50	MC1495	3.00	SN76660N	0.80	TBA560C	1.45	TDA2522	1.95
AN214Q	2.50	MC1496	1.25	SN76666N	0.70	TBA560CQ	1.45	TDA2523	1.95
AN240P	2.80	MC14011BCP	0.32	TA7061AP	3.95	TBA570	1.00	TDA2524	1.95
AN612	2.15	MC145106P	7.95	TA7108P	1.00	TBA641A12	2.50	TDA2530	1.95
AN7150	2.95	MC1723	0.50	TA7120P	1.65	TBA641BX1	3.00	TDA2532	1.95
BA521	3.35	MC3357	2.25	TA7130P	1.50	TBA651	1.75	TDA2540	1.25
CA3123E	1.35	ML231B	1.75	TA7146	2.95	TBA720A	2.45	TDA2541	2.15
ETT6016	2.50	ML232B	2.50	TA7176AP	3.95	TBA750Q	2.65	TDA2560	2.15
HA1551	2.95	ML237B	1.95	TA7203	2.95	TBA800	0.89	TDA2571	1.95
HA1156W	2.50	ML238B	4.20	TA7204P	2.15	TBA810AS	1.35	TDA2581	2.25
HA1366W	1.95	ML920	4.12	TA7205AP	1.50	TBA820Q	1.45	TDA2590	2.95
LA1230	1.15	MSM5807	6.75	TA7222AP	1.80	TBA890	2.50	TDA2591	2.95
LA4031P	2.70	PLL02A	5.75	TA7227P	4.25	TBA920	1.65	TDA2593	2.95
LA4102	2.95	SAA1025	7.25	TA7310P	1.80	TBA920Q	1.65	TDA2600	3.50
LA4400	4.15	SAA5000A	3.05	TA7313AP	2.95	TBA950/2X	2.35	TDA2610	2.50
LA4422	2.50	SAA5010	6.35	TA7321P	2.25	TBA990	1.49	TDA2611A	1.95
LC7120	3.25	SAS560S	1.75	TA7611AP	2.95	TBA990Q	1.49	TDA2640	2.60
LC7130	3.50	SAS570S	1.75	TAA550	0.25	TBA1441	2.15	TDA2690	1.35
LC7131	5.50	SAS580	2.85	TAA570	1.95	TCA270	1.10	TDA3560	3.95
LC7137	5.50	SL901B	4.85	TAA661B	1.20	TCA270SQ	1.10	TDA3950	1.95
LM56CH	0.95	SL917B	6.65	TAA700	1.70	TCA650	2.50	UPC566H	2.95
LM324N	0.45	SL1310	1.80	TAA6305	3.50	TCA800	2.15	UPC575C2	2.75
LM380N	0.95	SL1327	1.10	TBA120B	0.95	TCA830S	1.40	UPC1025H	2.50
LM383T	2.95	SL1327Q	1.10	TBA120S	0.70	TCA940	1.65	UPC1028H	1.95
LM390N	1.95	SN76003N	1.95	TBA120SA	0.70	TDA440	2.20	UPC1156H	2.75
M51513L	2.30	SN76013N	1.95	TBA120SQ	0.70	TDA1004A	2.20	UPC1167C2	1.15
M51515L	2.95	SN76013ND	1.95	TBA120T	1.05	TDA1006A	2.50	UPC1181H	1.25
M5152L	1.50	SN76023N	1.65	TBA120U	1.00	TDA1010	2.15	UPC1182H	2.95
MB3712	2.00	SN76033N	1.65	TBA231	1.25	TDA1035	2.50	UPC1185H	3.95
MC1307P	1.00	SN76110N	0.89	TBA395	1.50	TDA1037	1.95	UPC1350C	2.95
MC1310P	1.50	SN76131N	1.30	TBA396	0.75	TDA1170	1.95	UPC2002H	1.95
MC1327	0.95	SN76226DN	1.55	TBA440N	2.55	TDA1170S	1.95	ZTK33B	0.50
MC1327Q	0.95	SN76227N	1.05	TBA480Q	1.25	TDA1190	2.15	555	0.35
MC1330P	0.76	SN76532N	1.40	TBA510	2.50	TDA1270Q	3.95	556	0.42
MC1349P	1.20	SN76533N	1.65	TBA510Q	2.50	TDA1327	1.70	723	0.50
MC1350P	0.95	SN76544N	1.65	TBA520	1.10	TDA1352B	1.43	741	0.35
MC1351P	1.50	SN76650N	1.15	TBA520Q	1.10	TDA1412	0.85	747	0.50
MC1352P	1.25			TBA530	1.10	TDA2002	1.95	748	0.35
MC1357	2.35			TBA530Q	1.10	TDA2020	2.45	4042	0.50
MC1358	1.58			TBA540	1.25	TDA2030	2.80	7805	0.60
				TBA540Q	1.35				
				TBA550Q	1.45				

SEMICONDUCTORS

AAY12	0.25	BC173B	0.10	BD159	0.65	BF355	0.37	OC81	0.50
AC126	0.22	BC174	0.09	BD166	0.55	BF362	0.38	R2008B	1.70
AC127	0.20	BC174A	0.09	BD179	0.72	BF363	0.38	R2010B	1.70
AC128	0.20	BC177	0.15	BO182	0.70	BF371	0.20	R2322	0.58
AC128K	0.32	BC178	0.15	BD201	0.83	BF394	0.19	R2323	0.66
AC141	0.28	BC182	0.10	BD202	0.65	BF422	0.32	R2540	2.48
AC141K	0.34	BC182LB	0.10	BD203	0.78	BF457	0.32	RCA16334	0.90
AC142K	0.30	BC183	0.10	BD204	0.70	BF458	0.36	RCA16335	0.80
AC176	0.22	BC183L	0.09	BD222	0.46	BF459	0.36	SKE5F	1.45
AC176K	0.31	BC184LB	0.09	BD223	0.48	BF595	0.23	TIP29	0.40
AC187	0.25	BC204	0.10	BD225	0.48	BF597	0.25	TIP29C	0.42
AC187K	0.28	BC207B	0.13	BC232	0.35	BFR39	0.23	TIP30C	0.43
AC188	0.25	BC208B	0.13	BD233	0.35	BFR40	0.23	TIP31C	0.42
AC188K	0.37	BC212	0.09	BD234	0.35	BFR41	0.28	TIP32C	0.42
AD142	0.79	BC212L	0.09	BD236	0.45	BFR81	0.25	TIP33B	0.75
AD143	0.82	BC212LA	0.09	BD237	0.40	BFR88	0.30	TIP34B	0.75
AD149	0.70	BC213	0.09	BD238	0.40	BFR90	1.50	TIP41A	0.45
AD161	0.39	BC213L	0.09	BD241	0.40	BFR91	1.75	TIP41C	0.45
AD162	0.39	BC214	0.09	BD242	0.50	BFT42	0.28	TIP42C	0.47
AD161/2	0.90	BC214C	0.09	BD246	0.60	BFT43	0.28	TIP47	0.65
AF114	1.50	BC214L	0.09	BD376	0.32	BFW92	0.85	TIP120	0.60
AF124	0.34	BC237	0.10	BD410	0.55	BFX29	0.30	TIP125	0.65
AF125	0.35	BC237A	0.09	BD434	0.55	BFX84	0.26	TIP142	1.75
AF126	0.32	BC237B	0.09	BD437	0.50	BFX85	0.32	TIP146	2.75
AF127	0.32	BC238	0.09	BD438	0.60	BFX86	0.30	TIP161	2.95
AF139	0.40	BC239	0.12	BD506	0.50	BFX88	0.25	TIP2955	0.80
AF150	0.42	BC251A	0.12	BD508	0.40	BFY50	0.21	TIP3055	0.55
AF239	0.42	BC252A	0.15	BD520	0.65	BFY51	0.21	TIS91	0.20
AU106	2.00	BC258	0.25	BD538	0.65	BFY52	0.25	TV106/2	1.50
AU107	1.75	BC258A	0.39	BD597	0.75	BFY90	0.77	2N2219	0.28
AU110	2.00	BC284	0.30	BD697	1.10	BLY48	1.75	2N2905	0.40
AU113	2.95	BC300	0.30	BD698	1.10	BR100	0.26	2N3053	0.40
BC107A	0.11	BC301	0.30	BD707	0.80	BR101	0.30	2N3054	0.59
BC107B	0.11	BC303	0.26	BDX32	1.50	BRC4443	0.85	2N3055	0.52
BC108	0.10	BC307	0.09	BDY57	1.65	BT106	1.49	2N3702	0.12
BC108A	0.11	BC307A	0.09	BF115	0.35	BT108	1.49	2N3703	0.12
BC108B	0.12	BC307B	0.09	BF127	0.24	BT116	1.20	2N3704	0.12
BC109	0.10	BC327	0.10	BF154	0.12	BT119	1.65	2N3705	0.12
BC109B	0.12	BC328	0.10	BF158	0.22	BT120	1.65	2N3706	0.12
BC109C	0.12	BC337	0.10	BF160	0.27	BU105	1.22	2N3708	0.12
BC114	0.11	BC338	0.09	BF167	0.24	BU108	1.69	2N3773	1.95
BC116A	0.15	BC347A	0.13	BF173	0.22	BU124	1.25	2N3792	1.35
BC117	0.19	BC461	0.35	BF177	0.38	BU125	£1.25	2N4427	1.50
BC119	0.24	BC478	0.20	BF178	0.26	BU126	1.60	2N4444	1.15
BC125	0.25	BC527	0.20	BF179	0.34	BU204	1.55	2N5294	0.42
BC139	0.20	BC547	0.10	BF180	0.29	BU205	1.30	2N5296	0.48
BC140	0.31	BC548	0.10	BF181	0.29	BU208	1.39	2N5298	0.60
BC141	0.25	BC549A	0.08	BF182	0.29	BU208A	1.52	2N5496	0.65
BC142	0.21	BC550	0.08	BF183	0.29	BU326	1.20	2SA715	0.60
BC143	0.24	BC557	0.08	BF184	0.28	BU407	1.24	2SC495	0.80
BC147	0.09	BC557A	0.08	BF185	0.28	BU500	2.25	2SC496	0.80
BC147B	0.09	BC557B	0.08	BF194	0.11	BU526	1.90	2SC1096	0.80
BC148A	0.09	BC558	0.10	BF195	0.11	BUY69B	1.70	2SC1172Y	2.20
BC148B	0.09	BCY33A	1.60	BF196	0.11	MJ3000	1.98	2SC1173	1.15
BC149	0.09	BD115	0.30	BF197	0.11	MJE340	0.40	2SC1306	1.00
BC157	0.12	BD116	0.60	BF198	0.16	MJE520	0.48	2SC1307	1.50
BC158	0.09	BD124P	0.59	BF199	0.14	MPSA12	0.20	2SC1449	0.80
BC159	0.09	BD131	0.32	BF200	0.40	MPSA13	0.20	2SC1678	1.25
BC160	0.28	BD132	0.35	BF241	0.15	MPSA92	0.30	2SC1945	2.10
BC161	0.28	BD133	0.40	BF245	0.30	MRF450A	12.50	2SC1953	0.95
BC170B	0.15	BD135	0.30	BF246	0.28	MRF453	17.50	2SC1957	0.80
BC171	0.09	BD136	0.30	BF256/LC	0.28	MRF454	23.50	2SC1969	1.95
BC171A	0.10	BD137	0.32	BF257	0.28	MRF475	2.50	2SC2028	1.15
BC171B	0.10	BD138	0.30	BF258	0.28	MRF477	10.00	2SC2029	1.95
BC172	0.10	BD139	0.32	BF259	0.28	OC23	1.50	2SC2078	1.45
BC172B	0.10	BD140	0.30	BF271	0.26	OC42	0.55	2SC2091	0.85
BC172C	0.10	BD144	1.10	BF273	0.13	OC44	0.75	2SC2166	1.95
				BF336	0.34	OC45	0.55	2SC2314	0.80
				BF337	0.29	OC70	0.45	2SD234	0.50
				BF338	0.32	OC71	0.40	3N211	1.95

DIODES

AA119	0.08	BY199	0.40	IN4004	0.05
BA102	0.17	BY206	0.14	IN4005	0.05
BA115	0.13	BY208-800	0.33	IN4006	0.06
BA145	0.16	BY210-800	0.33	IN4007	0.06
BA148	0.17	BY223	0.90	IN4148	0.02
BA154	0.06	BY298-400	0.22	IN4448	0.10
BA155	0.13	BY299-800	0.22	IN5401	0.12
BA156	0.15	BYX10	0.20	IN5402	0.14
BA157	0.30	BYX36-150R	0.20	IN5403	0.12
BAX13	0.04	BYX38-600R	0.60	IN5404	0.12
BAX16	0.06	BYX55-600	0.30	IN5405	0.13
BB105B	0.30	BYX71-600	0.60	IN5406	0.13
BT151	0.79	BZY95C30	0.35	IN5407	0.16
BY126	0.10	OA47	0.09	IN5408	0.16
BY127	0.11	OA90	0.05	ITT44	0.04
BY133	0.15	OA91	0.06	ITT923	0.15
BY164	0.45	OA95	0.06	ITT2002	0.10
BY176	1.20	OA202	0.10		
BY179	0.63	IN914	0.04		
BY182	0.55	IN4001	0.04		
BY184	0.35	IN4002	0.04		
		IN4003	0.04		

74LS SERIES
Prices available on request

CRT TUBES

A selection available. Prices on request.

3BPI	£13.50	D10-210GH	£45
DG7-32	£42	DH7-91	£59
DP7-6	£35	DP7-11	£35
SE4DP7	£45	95447	£135
M17-151GVR	£220		

DATA & EQUIV. BOOKS

Transistor Data Books including Japanese types. Two books £8.50 pair.

I.C. DATA BOOKS
TOWERS £9.95 each
LIN 2 covering Regulators £4.95 each

www.americanradiohistory.com

PHONE
0474 813225
3 LINES

P. M. COMPONENTS LTD

SELECTRON HOUSE, WROTHAM ROAD
MEOPHAM GREEN, MEOPHAM, KENT DA13 0QY

TELEX
966371
PM COMP

BARCLAYCARD VISA

Fast with Access

A SELECTION FROM OUR STOCK OF BRANDED VALVES

A1714	18.50
A1998	11.50
A2087	11.50
A2134	14.95
A2293	6.50
A2521	21.00
A2599	37.50
A2900	11.50
A3042	24.00
A3283	24.00
AC/HL/DD	4.00
ACP	4.00
AC/THI	4.00
ACT22	59.75
AC/VP2	4.00
AC/S2 FEN	8.50
AH221	39.00
AH238	39.00
AL60	6.00
ARP12	0.70
ARP34	1.25
ARP35	2.00
BL63	2.00
BS450	67.00
CIK	16.00
C3JA	16.00
C110	55.00
C1134	32.00
C1148A	115.00
C1149/1	130.00
C1150/1	135.00
C1534	32.00
CBL31	2.00
CCA	2.60
CC3L	0.90
CL33	2.00
CMG25	9.00
CV Nos Prices on request	
D63	1.20
DAF91	0.45
DAF96	0.65
DC70	1.75
DC90	1.20
DCX4-1000	12.00
DCX4-5000	25.00
DET10	6.00
DET22	28.00
DET24	39.00
DET25	22.00
DF91	0.70
DF92	0.60
DF96	0.65
DH63	1.20
DH77	0.90
DH79	0.56
DH149	2.00
DK91	0.90
DK92	1.20
DK96	2.50
DL35	1.00
DL63	1.00
DL70	2.50
DL73	2.50
DL91	1.50
DL92	0.60
DL93	1.10
DL94	2.50
DL96	2.50
DLS10	8.00
DLS16	10.00
DM70	1.10
DM160	2.75
DY51	1.00
DY80	1.20
DY86/87	0.65
DY802	0.72
E1T	9.00
E80CC	7.00
E80CF	10.00
E80F	13.50
E80L	11.50
E81CC	3.50
E81L	12.00
E82CC	3.50
E83CC	3.50
E83F	3.50
E86C	9.50
E88C	7.95
E88CC	2.60
E90CC	5.00
E90F	7.95
E91H	4.50
E92CC	2.25
E99F	6.99
E130L	19.95
E180CC	6.50
E182CC	9.00
E180F	6.50
E186F	8.50
E280F	19.50
E283CC	10.00
E288CC	13.50
E810F	16.00
E1148	1.00
E1524	6.95
EA50	1.00
EA76	1.95
EA79	1.95

EAA91	0.60
EABC80	0.68
EAC91	2.50
EAF42	1.20
EAF801	1.40
EB34	1.50
EB41	3.00
EB91	0.52
EBC33	2.50
EBC41	1.95
EBC81	0.85
EBC90	0.75
EBC91	0.75
EBF33	2.50
EBF80	0.50
EBF83	0.50
EBF85	0.95
EBF89	0.70
EBF93	0.95
EBL1	2.50
EBL21	2.00
EC52	0.75
EC70	0.75
EC80	4.25
EC81	4.50
EC86	1.00
EC88	1.00
EC90	0.70
EC91	7.00
EC92	1.25
EC93	0.80
EC95	7.00
EC97	1.10
EC8010	6.00
ECC32	3.00
ECC33	3.50
ECC35	3.50
ECC40	3.00
ECC81	0.95
ECC82	0.55
ECC82 Philips	1.10
ECC83	0.65
ECC83 Mullard	1.35
ECC83 Philips	1.10
ECC84	0.50
ECC85	0.60
ECC86	1.45
ECC88	0.85
ECC91	2.00
ECC180	0.72
ECC189	0.78
ECC801S	3.50
ECC803S	3.50
ECC804	0.60
ECC807	2.50
ECC2000	12.00
ECF80	0.85
ECF82	0.85
ECF86	1.70
ECF200	1.85
ECF202	1.85
ECF801	0.85
ECF804	6.00
ECF805	2.50
ECF806	10.25
ECH3	2.50
ECH4	3.00
ECH35	1.60
ECH42	1.00
ECH81	0.58
ECH83	0.78
ECH84	0.69
ECH2000	1.50
ECL80	0.60
ECL82	0.65
ECL83	2.50
ECL84	0.74
ECL85	0.69
ECL86	0.74
ECL805	0.69
ECLL800	16.95
ED5100	3.50
EF37A	2.00
EF39	1.00
EF41	3.50
EF42	3.50
EF50	2.50
EF55	3.50
EF71	1.50
EF72	1.20
EF73	1.00
EF80	0.55
EF83	3.50
EF85	0.50
EF86	1.25
EF86 Special quality	2.50
EF89	0.85
EF91	1.25
EF92	2.50
EF93	0.69
EF94	0.85
EF95	1.00
EF97	0.90
EF98	0.90
EF183	0.65
EF184	0.65
EF730	1.80

EF731	1.80
EF732	1.80
EF800	11.00
EF804S	11.50
EF805S	13.50
EF806S	14.50
EF812	0.65
EFL200	1.50
EH90	0.72
EK90	0.72
EL32	0.95
EL33	4.00
EL34	2.25
EL34 Philips	3.15
EL36	1.50
EL37	9.00
EL38	6.00
EL42	2.00
EL81	3.95
EL82	0.58
EL84	0.69
EL85	4.50
EL86	0.85
EL90	1.25
EL91	6.00
EL95	0.70
EL183E	3.50
EL183P	3.50
EL360	7.95
EL500	1.40
EL504	1.40
EL509	5.25
EL519	6.95
EL802	3.65
EL821	10.35
EL822	12.95
EM1	9.00
EM4	9.00
EM35	1.50
EM80	0.70
EM81	0.70
EM84	1.10
EM85	1.10
EM87	2.50
EN10	8.00
EN32	13.50
EN91	1.10
EN91(SQ)	2.50
EN92	4.50
ES1500	115.00
ET1	11.00
EY51	0.80
EY81	1.50
EY83	1.50
EY84	6.95
EY84W	10.00
EY86/87	0.50
EY88	0.55
EY91	5.50
EY500A	1.50
EY802	0.70
EZ35	0.75
EZ40	1.25
EZ41	1.25
EZ80	0.60
EZ81	0.60
EZ90	0.96
F6064	2.95
FW4/800	2.00
G1/371K	30.00
G55/1K	9.00
G180/2M	9.00
G240/2D	9.00
G400/1K	14.00
GC10B	17.50
GC10D	17.50
GC10/4B	17.50
GC10/4E	17.50
GC12/4B	17.50
GD86W	6.00
GDT120M	5.00
GE10	9.00
GN4	6.00
GN10	15.00
GR10G	4.00
GR10J	4.00
GS10C	12.00
GS10H	12.00
GS12D	12.00
GT1C	17.00
GT1C S/S	13.00
GTE175M	8.00
GTR150W	1.00
GU20	70.00
GXU1	13.50
GXU3	24.00
GY501	1.20
GY802	1.00
GZ30	1.00
GZ31	1.00
GZ32	1.00
GZ33	4.50
GZ34	2.15
GZ37	4.50
HAA91	1.00
HABC80	0.90
HBC90	0.75
HBC91	0.80
HF93	0.75
HF94	0.60

HK90	1.05
HL2K	3.50
HL23DD	4.00
HL41	3.50
HL41DD	3.50
HL42DD	3.50
HL90	0.70
HL92	1.50
HL133/DD	3.50
HR2	4.00
HY90	1.00
HVR2	3.00
K3/18	85.00
KT8C	7.00
KT33C	3.50
KT36	2.00
KT44	4.00
KT45	4.00
KT63	2.00
KT66 USA	7.15
KT66 GEC	10.50
KT77 Gold Lion	9.50
KT81	7.00
KT88 USA	8.00
KT88 Gold Lion	13.50
KTW61	2.00
KTW62	2.00
KTW63	2.00
KTZ63	2.50
L63	1.20
L102/2K	6.95
L120/2K	12.00
M502A	135.00
M537A	160.00
M5143	155.00
M8079	6.00
M8082	7.50
M8083	3.25
M8091	7.50
M8096	3.00
M8098	3.20
M8099	4.00
M8100	2.85
M8136	7.00
M8137	5.50
M8161	5.50
M8162	5.50
M8163	3.85
M8190	3.85
M8195	3.00
M8196	3.25
M8204	2.00
M8223	2.00
M8224	2.00
M8225	2.00
ME1400	4.00
ME1401	29.50
ME1402	29.50
ME1501	14.00
MH4	3.50
MHLD6	4.00
MS4B	5.50
MU14	1.50
N37	13.50
N78	14.95
OA2	0.85
OA2WA	1.50
OA3	2.50
OB2	0.85
OB2WA	1.25
OC2	2.50
OC3	1.50
OD3	1.70
OM4	1.00
OM5B	3.00
OM6	1.75
OM9	4.00
ORP43	2.50
ORP50	3.95
P61	2.50
P41	2.50
PABC80	0.50
PC86	0.75
PC88	0.75
PC92	3.50
PC97	1.10
PC800	1.10
PC900	0.75
PCC84	0.40
PCC85	0.54
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.10
PCL82	0.80
PCL83	2.50
PCL84	0.85

PCL85	0.80
PCL86	0.85
PCL200	1.60
PCL800	0.80
PCL805	0.80
PD500	3.50
PD510	3.85
PEN4DD	2.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PEN46	2.00
PFL200	1.25
PL21	2.50
PL33	1.25
PL36	0.95
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.65
PL88	1.00
PL95	1.75
PL302	1.00
PL345	12.50
PL500	0.95
PL504	0.95
PL508	1.95
PL509	4.85
PL519	4.95
PL802	5.50
PL802T	3.25
PL820	2.95
PL5557	29.50
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.52
PY500A	1.79
PY800	0.79
PY801	0.79
Q13-110BA	47.50
QB3-300	30.50
QEO3-10	3.50
QEO8-200	130.00
QP25	1.00
QQEO2-5	12.75
QQEO3-12	6.50
QQEO3-20	27.00
QQEO6-40	39.50
QQVO2-6	12.75
QQVO3-10	5.50
QQVO3-20	18.50
QQVO3-20A	17.00
QQVO3-20B	32.00
QQVO6-40A	18.00
QQVO7-50	63.50
QQZO3-20	42.50
QQZO6-40A	45.25
QS72/20	1.50
QS75/40	3.00
QS92/10	5.00
QS95/10	4.85
QS108/45	4.00
QS150/15	5.00
QS150/30	1.15
QS150/45	7.00
QS1200	3.95
QS1202	3.95
QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90
QS1208	0.90
QS1209	2.00
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	9.50
QU37	11.50
QVO3-12	4.95
QVD5-25	1.75
QVO6-20	29.50
QVO8-100	118.50
QY3-125	34.95
QY4-250	35.00
QY4-400	71.95
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	6.95
R20	1.20
RG1-125	4.95
RG1-240A	14.50
RG3-250A	3.50

RG3-1250A	52.50
RK2K25	62.50
RG4-1000	10.00
RK-20A	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	37.00
RR3-1250	65.00
RS613	45.00
RS685	54.95
RS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
S30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.95
S130P	5.95
SC1/800	5.00
SC1/1200	5.00
SC1/2000	9.00
SP2	1.50
SP41	5.00
SP42	3.00
ST11	1.50
STV280/40	11.95
STV280/80	19.95
SU42	4.95
TB2.5/3000	60.00
TB2-300	45.00
TD1-100A	19.00
TD03-10D	35.00
TD03-10E	28.00
TDO3-10F	28.00
TD3-12	4.00
TP25	1.50
TSP4	7.00
TT11	1.50
TT15	34.95
TT21	23.50
TT22	23.50
TY2-125A	45.00
TY4-400	65.00
TY6-800	185.00
TY7-6000A	365.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U54	4.50
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U291	0.60
U301	0.55
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	1.75
UBC81	1.50
UBF89	0.60
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	1.20
UCH42	1.35
UCH81	0.65
UF85	1.20
UF41	1.15
UF42	1.15
UF80	0.80
UF89	2.50
UL41	3.50
UL84	0.85
UU5	2.50
UU7	8.00
UY41	3.50
UY85	0.70
V339	3.50
V2351AK	249.50
VLS631	10.95
VP2B	2.50
VP4A	4.50
VP4B	4.50
VP6	2.50
VP41	2.50
VP133	2.00

VR37	1.50
VR75/30	3.00
VR91	1.50
VR101	2.00
VR105/30	1.50
VR150/30	1.05
VT52	2.50
VU39	1.50
VX6120	5.00
VX9133	5.00
VX9181	5.00
W77	5.00
W729	1.00
W739	1.50
X24	1.00
X66L	4.95
X76M	1.95
X79	3.50
XC12	1.50
XC15	1.50
XC25	0.50
XE3P	2.50
XFW47	1.50
XFW50	1.50
XG5-500	22.50
XL1-5V	1.50
XNP12	2.50
XNP28	2.50
XP1002	29.00
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	99.50
XSG2-0	3.00
Y63	1.50
Y65	6.95
Y602	12.00
YJ1060	285.00
YL1020	29.00
YL1070	115.00
YL1071	109.00
YL1370	5.50
YL1371	8.50
Z77	1.20
Z302C	12.00
Z303C	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z800U	3.00
Z801U	3.00
Z803U	18.95
ZA1000	9.00
ZA1001	1.50
ZA1002	1.50
ZC1040	8.00
ZM1000	8.95
ZM1001	5.00
ZM1005	8.00
ZM1020	8.95
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1050	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
2T1011	29.00
1AC6	1.20
1B3GT	1.95
1B5	2.50
1B22	10.00
1B24	14.95
1C1	1.20
1C5GT	1.00
1D5	1.00
1FD1	0.90
1G3GT	1.00
1L4	0.60
1L6	1.50
1LA6	1.00
1N5GT	2.50
1S2	0.55
1T4	0.45
1U5	1.00
1X2B	1.15
2AS15A	10.00
2C21	1.00
2C39A	23.50
2C39BA	39.50
2C40	37.00
2C40A	55.00
2C42	29.50
2C43	29.50
2C51	0.75
2C53	32.00
2B7	1.50
2D21	0.95
2D21W	2.50
2E26	7.95
2J42	93.00
2K25	24.95
3A/107B	12.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00

3A2	3.95
3A3A	3.95
3A4	1.10
3AL5	0.95
3AT2	3.35
3AW2	3.35
3B2	3.00
3B7	4.50
3B24	7.50
3B28	12.00
3C4	1.00
3C45	17.50
3CN3A	2.50
3CX3	2.50
3D21A	29.50
3D22	19.50
3J187E	398.00
3J187G	398.00
3W4GT	2.50
4B551B	115.00
4-65A	59.00
4-250A	65.00
4C27	25.00
4C28	25.00
4CX250B	37.50
4CX250R	48.50
4CX350A	71.50
4GS7	2.25
4GV7	2.25
4X150A	25.00
5A152M	9.00
5A163K	10.00
5A170K	0.25
5AN8	1.20
5AR4	2.00
5AU4	1.50
5B.110M	10.00
5B-254M	14.50
5B-255M	14.50
5B-257M	9.00
5B-258M	14.50
5C22	40.00
5R4GB	2.80
5R4GY	2.80
5U4G	1.00
5U4GB	2.50
5V4G	0.75
5Y3GT	0.80
5Z4GT	0.85
6/30L2	0.70
6A/203K	9.00
6A8G	1.50
6AB7	0.60
6AB8	0.85
6AC7	2.00
6AF4A	2.50
6AG5	1.50
6AG7	1.95
6AH6	1.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.00
6AK6	2.00
6AL5	0.52
6AM4	3.25
6AM5	8.00
6AM6	1.20
6AN5	3.95
6AN8A	2.15
6AQ5	1.20
6AQ8	0.85
6AR5	2.00
6AR8	2.00
6AS5	1.50
6AS6	1.50
6AS7G	7.50
6AT6	0.75
6AU4	2.00
6AU6	0.85
6AV6	0.72
6AW8A	2.95
6B8G	1.50
6BA6	0.69
6BA6W	1.50
6BA7	4.50
6BA8A	3.50
6BC8	1.00
6BD4	1.50
6BD6	1.00
6BE6	0.72
6BF5	1.80
6BG6G	1.25
6BH6	1.95
6BH8	1.50
6BJ6	1.20
6BK4	4.00
6BK7A	1.95
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN7	4.50
6BN8	2.75
6BQ5	0.69
6BQ7A	0.72
6BL7GTA	3.95
6BL8	0.65
6BR5	0.70
6BR7	4.15
6BR8	2.15
6BR8A	2.15
6BS7	4.50
6BS8	2.50
6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00

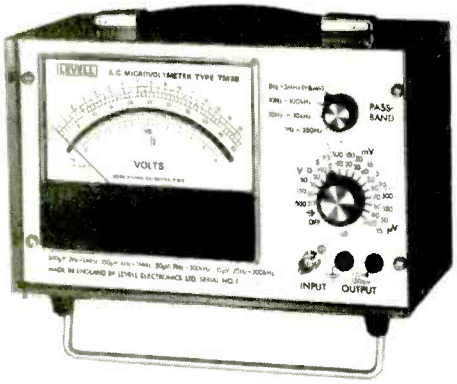
6BX6	0.48
6BX7GT	3.50
6BZ6	2.00
6BZ7	2.95
6BZ8	0.95
6C4	0.80
6C5	1.95
6C6	0.50
6C8G	1.50
6C11	2.50
6C15	2.50
6C18	2.50
6CA4	0.60
6CA7	4.50
6CB6	1.50
6CD6GA	4.50
6CF6	1.60
6CH6	10.35
6CL6	3.50
6CL8A	2.00
6CM5	1.60
6CS6	0.75
6CW4	7.25
6CY5	1.00
6DC6	2.00
6DK6	1.15
6DQ5	2.30
6DQ6B	2.50
6DR7	2.00
6EA8	2.50
6EB8	1.75
6EU8	1.75
6EW6	1.50
6F1	2.00
6F6G	2.00
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F18	1.50
6F19	0.48
6F21	2.50
6F22	0.70
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F33	17.00
6FG5	1.95
6GH8A	0.80
6GK5	1.50
6GK6	2.00
6GV7	2.50
6GW6	2.50
6H3N	1.10
6H6	1.35
6H6GT	1.20
6J4	1.10
6J5	1.95
6J5G	1.50
6J6	0.65
6J86A	3.95
6JE6C	3.95
6JS6C	3.50
6K7G	0.70
6K8Y	3.95
6KD6	4.50
6L1	2.50
6L19	3.95
6L6GC	2.75
6L6GT	1.15
6L7G	0.75
6LD20	0.50
6LF6	2.95
6LQ6	3.95
6N7	2.50
6N7GT	1.50
6P15	0.80
6P25	4.00
6P28	2.00
6Q7	1.20
6Q7GT	1.20
6S7	1.10
6SA7GT	1.00
6SC7	1.50
6SG7	1.20
6SH7	1.20
6SJ7GT	1.20
6SK7	0.80
6SK7GT	1.20
6SL7GT	0.72
6SN7GT	0.69
6SQ7	0.80
6SS7	1.95
6J4GT	1.75
6J5G	1.50
6J8	0.85
6J8A	1.50
6V6GT	0.80
6X2N	1.00
6X4	0.96
6X5GT	0.50
6X5GTY	1.00
6X8A	2.25
7A7	2.00
7AD7	1.75
7B7	1.40
7C5	3.00
7C6	2.50
7H7	2.00
7Q7	2.00
7S7	3.00
7Y4	1.95
8FQ7	1.95
10C1	5.50
10C2	0.70

10D2	1.25
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD11	1.00
10LD12	0.65
11E2	16.50
11E3	55.00
12AE6	0.85
12AG8	1.50
12AL5	1.00
12AT6	0.59
12AT7	0.95
12AT7WA	2.50
12AU6	1.50
12AU7	0.55
12AV6	0.80
12AX4GT	1.00
12AX7	0.65
12AX7WA	2.50
12AYZ	4.00
12AZ7A	1.95
12B4A	3.50
12BA6	1.50
12BE6	1.05
12BH7A	1.80
12BL6	0.70
12BY7A	2.75
12CX6	1.20
12E1	17.95
12E14	28.00
12GN7	3.95
12HG7A	3.95
12J7GT	0.70
12K5	1.00
12K7GT	0.60
12K8	1.10
12Q7GT	0.60
12SA7GT	1.00
12SH7	1.00
12SK7	1.00
12SJ7	0.60
12SN7GT	1.85
12U7	1.50
13D3	3.20
13D7	3.20
13E1	115.00
14S7	1.00
15E	1.00
17DW4A	1.75
17JZ8	2.75
18D3	1.60
19AQ5	1.15
19G3	17.00
19H4	23.95
19Q6	9.00
20A2	10.50
20D1	0.70
20D4	1.75
20LF6	3.50
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.05
20P5	1.15
21LU8	2.50
25L6GT	1.75
25BQ6	1.75
29C1	19.50
30	2.85
30C1	0.70
30C15	0.40
30C17	0.40
30C18	1.48
30F5	0.95
30FL1	1.00
30FL2	1.00
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6A	4.15
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.85
38HE7	4.50
40KD6	4.50
47	6.00
50B5	1.50
50C5	0.95
50CD6G	1.15
52KU	2.00
61SPT	4.50
75B1	1.50
75C1	1.70
83A1	7.00
84	3.00
85A1	6.50
85A2	2.00
90AV	10.00
90C1	2.70
90CG	13.50
91AG	9.00
92AG	12.50
92AV	12.50

95A1	6.50
108C1	1.50
150B2	3.95
150C2	1.50
150C4	2.15
155UG	25.00
185BT	1.50
205F	12.00
257A	6.00
307	5.00
329	5.00
388A	17.50
425A5	8.00
431U	2.00
572B	35.00
705A	8.00
708A	8.00
715A	6.00
715C	45.00
725A	275.

AF & RF MICROVOLTMETERS

LEVELL A.C. MICROVOLTMETERS AND BROADBAND VOLTMETERS are part of our comprehensive range of test and measuring instruments. They are housed in robust steel cases and are powered by long life batteries. These voltmeters give accurate readings over a wide range of frequencies. Mains power units and leather carrying cases are optional extras.



A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES	15μV, 50μV, 150μV . . . 500V fsd. Acc. ±1% ±1% fsd ± 1μV at 1kHz, −100, −90 . . . +50dB. Scale −20dB/+6dB ref. 1mW/600Ω.	type TM3A £140
RESPONSE	±3dB from 1Hz to 3MHz, ±0.3dB from 4Hz to 1MHz above 500μV. TM3B filter switch; LF cut 10Hz. HF cut 100kHz, 10kHz, or 350Hz.	type TM3B £156
INPUT IMPEDANCE	Above 50mV: 10MΩ <20pF. On 50μV to 50mV: >5MΩ <50pF.	

BROADBAND VOLTMETERS

L.F. RANGES	As A.C. Microvoltmeters.	type TM6A £220
H.F. VOLTAGE & dB RANGES	1mV, 3mV, 10mV . . . 3V fsd. Acc. ±4% ±1% fsd at 30MHz, −50, −40 . . . +20dB. Scale −10dB/+3dB ref. 1mW/50Ω.	type TM6B £240
H.F. RESPONSE	±3dB from 300kHz to 400MHz. ±0.7dB from 1MHz to 50MHz.	

Send for data covering our range of instruments. Prices are plus carriage, packing and VAT.

LEVELL ELECTRONICS LTD. Moxon Street, High Barnet, Herts. EN5 5SD Tel: 01-449 5028/440 8686

WW – 013 FOR FURTHER DETAILS

If you missed out on Breadboard '79, '80, '81 and '82 . . . . Now's the time to catch up with

THE PREMIER SHOW FOR THE ELECTRONICS ENTHUSIAST!

BREAD BOARD '83

CUNARD INTERNATIONAL EXHIBITION CENTRE, CUNARD HOTEL, HAMMERSMITH, LONDON W6.

Friday November 25th 10am-6pm
Saturday November 26th 10am-6pm
Sunday November 27th 10am-4pm

Improved Venue
Offering improved facilities to the visitor, including car parking and ease of access by rail, tube and car, all in a modern attractive setting.

Holiday Weekend
Why not bring your partner to the show and enjoy a weekend in London? A complete hotel package is available to our visitors to the exhibition with all inclusive rail tickets. Send now for details of what we, the organisers, can offer you.

Write to:
Breadboard '83
ASP Exhibitions
145 Charing Cross Road
London WC2H 0EE

This year's features include

- Computer controlled model railway competition. (send off for entry form now)
- Kits components and tools to build all sorts of projects
- Robotic display
- Components and tools at bargain prices
- Technical advice on electronics projects and Ham Radio technique
- Computer Corner – 'Try before you buy'
- Lectures by professionals covering aspects of electronics and computing
- Holography and Producing Printed Circuit Boards.
- Pick of the projects – Demonstration of the best from ELECTRONICS TODAY INTERNATIONAL, HOBBY ELECTRONICS AND ELECTRONICS DIGEST.

www.americanradiohistory.com

To obtain further details of any of the coded items mentioned in the editorial or advertisement pages of this issue, please complete one or more of the attached cards entering the reference number(s). Your enquiries will be passed on to the manufacturers concerned and you can expect to hear from them direct in due course. Cards posted from abroad require a stamp. These service cards are valid for six months from the date of publication.

Please use capital letters

If you are way down on the circulation list, you may not be getting the information you require from the journal as soon as you should. Why not have your *own* copy?

To start a one year's subscription you may apply direct to us by using the card at the bottom of this page. You may also apply to the agent nearest to you: their address is shown below.

OVERSEAS SUBSCRIPTION AGENTS

Australia: Gordon & Gotch (Australasia) Ltd, 380 Lonsdale Street, Melbourne 3000, Victoria

Belgium: Agence et Messageries de la Presse, 1 Rue de la Petite-ILE Brussels 7

Canada: Davis Circulation Agency, 153 St. Clair Avenue West, Toronto 195, Ontario

Cyprus: General Press Agency Ltd, 131 Prodromou Street, P.O. Box 4528, Nicosia

Denmark: Dansk Bladdistribution, Hovedvagtsgade 8, Dk. 1103 Kobenhavn.

Finland: Rautakirja OY, Koivuvaarankaja 2, 01640 Vantaa 64, Finland.

France: Dawson-France S.A., B.P.40, F-91121, Palaiseau

Germany: W. E. Saarbach GmbH, 5 Koln 1, Follerstrasse 2

Greece: Hellenic Distribution Agency, P.O. Box 315, 245 Syngrou Avenue, Nea Smyrni, Greece.

Holland: Van Ditmar N.V., Oostelijke Handelskade 11, Amsterdam 1004

India: International Book House, Indian Mercantile Mansion Ext, Madame Cama Road, Bombay 1

Iran: A.D.A., 151 Khiaban Soraya, Tehran

Israel: Steimatzky's Agency Ltd, Citrus House, P.O. Box 628, Tel Aviv

Italy: Intercontinental s.a.s. Via Veracini 9, 20124 Milano

Japan: Western Publications Distribution Agency, 170 Nishi-Okubo 4-chome, Shinjuku-Ku, Tokyo 160

Lebanon: Levant Distributors Co., P.O. Box 1181, Makdesi Street, Halim Hanna Bldg, Beirut

Malaysia: Times Distributors Sdn. Bhd., Times House, 390 Kim Seng Road, Singapore 9, Malaysia.

Malta: W. H. Smith Continental Ltd, 18a Scots Street, Valleta

New Zealand: Gordon & Gotch (New Zealand) Ltd, 102 Adelaide Road, Wellington 2

Nigeria: Daily Times of Nigeria Ltd, 3 Kekawa Street, P.O. Box 139, Lagos

Norway: A/S Narvesens Kioskompani, Bertrand Narvesens vei 2, Oslo 6

Portugal: Livaria Bertrand s.a.r.l Apartado 37, Amadora

South Africa: Central News Agency Ltd, P.O. Box 1033, Johannesburg

Spain: Comercial Atheneum s.a. Consejo de Ciento, 130-136 Barcelona 15

Sweden: Wennegren Williams A B. Fack S-104, 25 Stockholm 30

Switzerland: Naville & Cie SA, Rue Levrier 5-7, CH-1211 Geneve 1 Schmidt Agence AG, Savogelstrasse 34, 4002 Basle

U.S.A.: John Barios, Business Press International, 205 East 42nd Street, New York, N.Y. 10017

CUT HERE

Postage will be paid by Licensee

Do not affix Postage Stamps if posted in Gt Britain, Channel Islands, N Ireland or the Isle of Man

BUSINESS REPLY SERVICE
Licence No CY258

WIRELESS WORLD
Reader Enquiry Service
Oakfield House
Perrymount Road
Haywards Heath
Sussex RH16 3DH

2

CUT HERE

Enquiry Service for Professional Readers

WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....

WIRELESS WORLD Wireless World, October 1983 WW 8370

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name .....

Name of Company .....

Address .....

.....

Telephone Number .....

PUBLISHERS USE ONLY			A/E			

Position in Company .....

Nature of Company/Business .....

No. of employees at this establishment .....

I wish to subscribe to Wireless World ☐

VALID FOR SIX MONTHS ONLY

CUT HERE

Wireless World: Subscription Order Form

To become a subscriber to Wireless World please complete the reverse side of this form and return it with your remittance to:

Subscription Manager,
Business Press International Ltd,
Oakfield House, Perrymouth Road
Haywards Heath, Sussex RH16 3DH
United Kingdom

www.americanradiohistory.com

Enquiry Service for Professional Readers only.

WIRELESS WORLD Wireless World, October 1983 WW 8370

WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name .....

Position in Company .....

Name of Company .....

Address .....

.....

Telephone Number .....

Nature of Company/Business .....

No. of employees at this establishment .....

VALID FOR SIX MONTHS ONLY

CUT HERE

Postage will be paid by Licensee

Do not affix Postage Stamps if posted in Gt Britain, Channel Islands, N Ireland or the Isle of Man

BUSINESS REPLY SERVICE
Licence No CY258

2

WIRELESS WORLD
Reader Enquiry Service
Oakfield House
Perrymount Road
Haywards Heath
Sussex RH16 3DH

CUT HERE

Wireless World *Subscription Order Form* Wireless World, October 1983 WW 8370

UK subscription rates
1 year: £14.00

Overseas ***1 year:*** £17.00

USA & Canada subscription rates
1 year: $44.00

Please enter my subscription to Wireless World for 1 year

I enclose remittance value.....**made payable to**

BUSINESS PRESS INTERNATIONAL Ltd.

Name.....

Address.....

.....

Company Registered No: 151537 (ENGLAND)
Registered Office: Quadrant House, The Quadrant, Sutton, Surrey SN2 5AS

CUT HERE

OVERSEAS ADVERTISEMENT AGENTS

Hungary Ms. Edit Bajusz, Hungexpo Advertising Agency, Budapest XIV, Varosliget – Telephone: 225 008 – Telex: Budapest 22-4525 INTFOIRE

Italy Sig. C. Epis Etas-Kompass, S.p.a. – Servizio Estero, Via Mantegna 6, 20154 Milan – Telephone 347051 – Telex: 37342 Kompass

Japan Mr. Inatsuki, Trade Media – IBPA (Japan), B212 Azabu Heights, 1-5-10 Roppongi, Minato-Ku, Tokyo 106 – Telephone : (03) 585-0581

United States of America Ray Barnes, *Business Press International
205 East 42nd Street,
New York, NY 10017 – Telephone: (212) 689 5961 – Telex: 421710
Jack Farley Jnr., The Farley Co.,
Suite 1548, 35 East Wacker Drive,
Chicago, Illinois 60601 – Telephone: (312) 6 3074
Victor A Jauch,
Elmatex International,
P.O. Box 34607,
Los Angeles Calif. 90034 U.S.A.
Telephone: (213) 821 8581
Telex: 18 – 1059.
Jack Mentel, The Farley Co., Suite 605, Ranna Building, Cleveland, Ohio 4415 – Telephone: (216) 621 1919
Ray Rickles, Ray Rickles & Co.,
P.O. Box 2008, *Miami Beach, Florida* 33140 – Telephone: (305) 532 7301
Jim Parks, Ray Rickles & Co.,
3116 Maple Drive N.E., Atlanta, Georgia 30305. Telephone: (404) 237 7432
Mike Loughlin, Business Press International, 15055 Memorials, Ste 119, Houston, Texas 77079 – Telephone: (713) 783 8673

Canada Colin H. MacCulloch, International Advertising Consultants Ltd., 915 Carlton Tower, 2 Carlton Street, Toronto 2 – Telephone (416) 364 2269

*Also subscription agents

www.americanradiohistory.com

AN OSCILLOSCOPE & FUNCTION GENERATOR IN ONE PRECISION INSTRUMENT FOR JUST £295 plus VAT

Made in Britain

You can now buy a dual trace oscilloscope and function generator and have it delivered anywhere in the UK mainland for less than £300.
Or, if you have a Scopex dual trace scope, the function generator can be supplied separately for you to fit.
Only Scopex offers this total add-on compatibility.

SCOPEXTFA FG Combined oscilloscope and function generator £295 plus VAT.
FG4,FG14/25 Function generator for mounting on Scopex dual trace scopes £69 plus VAT.
FG1 stand-alone function generator in instrument case £79 plus VAT.

SCOPEX
the oscilloscope people
Scopex Instruments Limited, Pixmore House, Pixmore Avenue, Letchworth, Herts SG6 1HZ
Telephone (04626) 72771

WW – 061 FOR FURTHER DETAILS

Largest range? Superior paint finish? Best ex-stock delivery?

Familiar claims? Study the Sarel range and decide for yourself. You'll find answers to all your own questions on enclosures — small, large, metal, plastic, glass-fibre reinforced polyester, monobloc, modular, with every imaginable accessory from gaskets to swing racks, chassis to brackets, locks, handles, glands and ventilators.

Sarel's range answers all your questions. No fuss, no bother, no compromise. Contact us for a quotation.

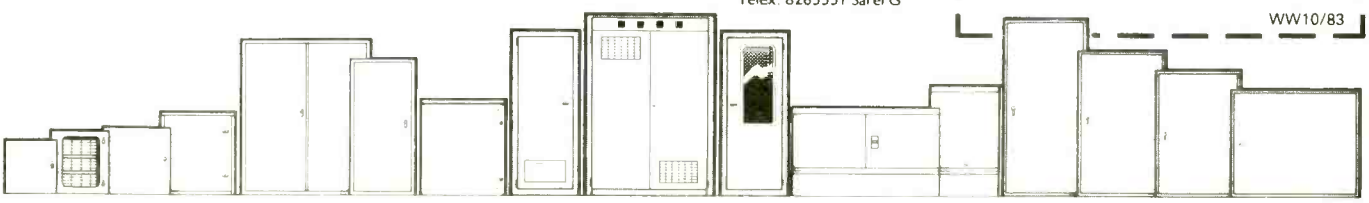
Think big – think Sarel
Sarel Electric Limited
Cosgrove Way, Luton, Beds. Tel: Luton 20121
Telex: 8265551 Sarel G

Send me my free copy of the new Sarel Electric catalogue, fast!

Name
Position
Company
Address

Telephone

WW10/83

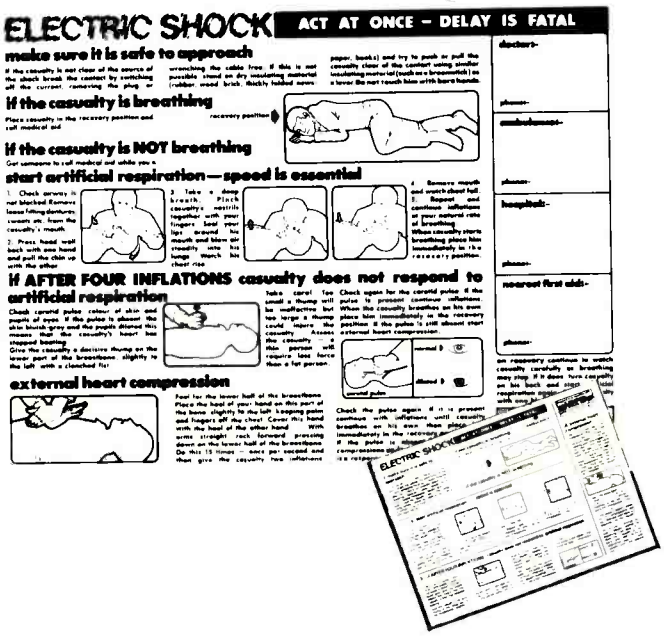


WW – 070 FOR FURTHER DETAILS

www.americanradiohistory.com

ELECTRIC SHOCK

2 WAYS TO RECOVERY



1 Display the ELECTRICAL REVIEW shock first aid chart (356 × 508mm) supplied in thousands to destinations world-wide. Recent deliveries include consignments to Bermuda, Egypt, Kenya, Oman, Pakistan, W. Germany, apart from UK commercial and industrial, educational, central government, local authorities' orders.

2 Carry the ELECTRICAL REVIEW pocket-size shock card (92 × 126mm) designed to help safety and training officers, medical and welfare personnel. Supplied to the *Royal Navy*, other Defence establishments, lighthouses, North Sea gas terminals, nuclear and hydro-electric power stations, docks, breweries, road and water authorities; enterprises in Ghana, Ireland, Kenya, Kuwait and South Africa as well as UK commercial, educational and industrial organisations.

BE READY TO SAVE LIFE. SOMEONE MIGHT SAVE YOU.

To Electrical-Electronic Press,
General Sales Department,
Room 108,
Quadrant House,
Sutton, SM2 5AS,
Surrey,
England.

Company registered in England No 151537. Registered Office Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

Please send . . . . . copy/copies as indicated.

Pocket Card @ 70p each ☐
Paper Chart @ £1.00 each ☐ Post
Card Chart @ £2.00 each ☐ free in
Plastic Chart @ £3.00 each ☐ UK
Cheque/p.o. enclosed for £. . . . . .
payable to
BUSINESS PRESS INTERNATIONAL Ltd.
(Overseas surface and air mail rates supplied on application, Tel. 01-661 8668; Telex 892084 BISPRS G.)

Name . . . . . .
Address . . . . . .
. . . . . .
. . . . . .

www.americanradiohistory.com

COMPUTER WAREHOUSE

THE 'ALADDIN'S' CAVE OF COMPUTER AND ELECTRONIC EQUIPMENT

HARD DISK DRIVES

Fully refurbished Diablo/DRE Series 30 2.5 mb hard disk drive for DEC RK05, NOVA, TEXAS etc.
Front load £550.00 – Top load £295.00
PSU type ME3029 for 2 drives £125.00

DRE 44A/4000A/B 10 mb 5+5 all configurations from £995.00. Call sales office for details.

5 AMP MAINS FILTERS

Cure those unnerving hang ups and data glitches caused by mains interference. Matchbox size – Up to 5 amp 240 v load. As recommended by the ZX81 newsletter. Suppression Devices SD5A £5.95.

DISTEL©

The UK's **FIRST** free of charge, 24 hr. public access data base. Get information on **1000's** of stock items and order via your computer and credit card. On line now, 300 baud. CCITT tones, full duplex, fully interactive.

DON'T MISS THOSE BARGAINS CALL NOW, IT'S FREE!

01-683 1133 7 days per week 24 hrs. per day

8 BIT WORD – NO PARITY

COMPUTER 'CAB'

All in one quality computer cabinet with integral switched mode PSU, Mains filtering, and twin fan cooling. Originally made for the famous **DEC PDP8** computer system costing thousands of pounds. Made to run 24 hours per day the PSU is fully screened and will deliver a massive +5v DC at 17 amps, +15v DC at 1 amp and –15v DC at 5 amps. The complete unit is fully enclosed with removable top lid, filtering, trip switch, 'Power' and 'Run' LEDs mounted on Ali front panel, rear cable entries, etc. etc. Units are in good but used condition – supplied for 240v operation complete with full circuit and tech. man. **Give your system that professional finish** for only £49.95 + Carr. Dim. 19" wide 16" deep 10.5" high. Useable area 16"w 10.5"h 11.5"d.
Also available **LESS PSU**, with FANS etc. Internal dim. 19"w. 16"d. 10.5"h. ***£19.95***. Carriage & insurance £9.50.

COOLING FANS

Keep your hot parts COOL and RELIABLE with our range of **BRAND NEW** professional cooling fans.
ETRI 99XU01 Dim. 92 x 92 x 25 mm. Miniature 240 v equipment fan complete with finger guard. **£9.95.**
GOULD JB-3AR Dim. 3" x 3" x 2.5" compact very quiet running 240 v operation. **NEW £6.95**
BUHLER 69.11.22. 8-16 v DC micro miniature reversible fan. Uses a brushless servo motor for extremely high air flow, almost silent running and guaranteed 10,000 hr life. Measures only 62 x 62 x 22 mm. Current cost £32.00. **OUR PRICE ONLY £12.95 complete with data.**
MUFFIN-CENTAUR standard 4" x 4" x 1.25" fan supplied tested EX EQUIPMENT 240 v at £6.25 or 110 v at £4.95 or BRAND NEW 240 v at £10.50. 1000's of other fans Ex Stock. Call for Details. Post & Packing on all fans £1.60

8" FLOPPY DISK DRIVES

Unbelievable value the DRE 7100 8" floppy disk drives utilise the finest technology to give you 100% bus compatibility with most drives available today. The only difference being our **PRICE** and the superb manufacturing quality!! The 7100 single sided drive accepts hard or soft sectoring IBM or ANSI standard formats giving a massive 0.8 MB of storage. Absolutely SHUGART, BASF, SIEMENS etc. compatible. Supplied BRAND NEW with user manual and full 90 day warranty. **7100 Single sided £225.00** + Carriage and insurance £10.00.

Optional accessories: Full technical manual £20.00 alone. £10.50 with drive. Refund of difference on drive purchase. DC and AC power connector and cable kit £8.45. 50 way IDC connector £5.50. 50 way ribbon cable £3.20 per metre.

RECHARGEABLE NICADS

SAFT VR2C 1.2v 'C' size nicads. 18 cells in ex equipment pack. Good condition – easily split to single cells. ***£9.50*** + £1.90 post and packing.

VIDEO MONITORS

12" CASED. Made by the British KGM Co. Designed for continuous use as a data display station, unit is totally housed in an attractive brushed aluminium case with ON-OFF, BRIGHTNESS and CONTRAST controls mounted to one side. Much attention was given to construction and reliability of this unit with features such as, internal transformer isolated regulated DC supply, all components mounted on two fibre glass PCB boards – which hinge out for ease of service, many internal controls for linearity etc. The monitor accepts standard 75 ohm composite video signal via SO239 socket on rear panel. Bandwidth of the unit is estimated around 20 Mhz and will display most high def graphics and 132 x 24 lines. Units are secondhand and may have screen burns. However where burns exist they are only apparent when monitor is switched off. Although unguaranteed all monitors are tested prior to despatch. Dimensions approx. 14" high x 14" wide by 11" deep. Supplied complete with circuit. 240 volt AC operation. ***ONLY £45.00 PLUS £9.50 CARR.***

24" CASED. Again made by the KGM Co with a similar spec as the 12" monitor. Originally used for large screen data display. Very compact unit in lightweight alloy case dim. 19" H x 17" D x 22" W. All silicon electronics and composite video input make an ideal unit for schools, clubs, shops etc. Supplied in a used but working condition.
ONLY £55.00 PLUS £9.50 CARR. & INS.

14" COLOUR superb chassis monitor made by a subsidiary of the HITACHI Co. Inputs are TTL RGB with separate sync. and will plug direct into the BBC micro etc. Exceptional bandwidth with good 80 col. definition. Brand new and guaranteed. Complete with full data & circuit. 240 v AC working. Dim. 14" x 13" x 13"
ONLY £199.00 PLUS £9.50 CARR.

SUPER DEAL? NO — SUPER STEAL!!

The FABULOUS 25CPS TEC Starwriter
Daisy wheel printer at a fraction of its original cost.

BRAND NEW AT ONLY £499 + VAT

Made to the very highest spec the **TEC Starwriter FP1500-25** features a heavy duty die cast chassis and DIABLO type print mechanism giving superb registration and print quality. Micro-processor electronics offer full DIABLO/QUME command compatability and full control via CPM Wordstar etc. Many other features include bi directional printing, switchable 10 or 12 pitch, full width 381 mm paper handling with upto 163 characters per line, friction feed rollers for single sheet or continuous paper, internal buffer, standard RS232 serial interface with handshake. Supplied absolutly **BRAND NEW** with 90 day guarantee and **FREE** daisy wheel and dust cover. Order **NOW** or contact sales office for more information. Optional extras: RS232 data cable **£10.00**. Tech manual **£7.50**. Tractor feed **£140.00**. Spare daisy wheel **£3.00**. Carriage & Ins. (UK Mainland) **£10.00**.

TELETYPE ASR33 I/O TERMINALS

FROM £195 + CAR. + VAT

Fully fledged industry standard ASR33 data terminal. Many features including ASCII keyboard and printer for data I/O auto data detect circuitry. RS232 serial interface. 110 baud. 8 bit paper tape punch and reader for off line data preparation and ridiculously cheap and reliable data storage. Supplied in good condition and in working order.
Options: Floor stand ***£12.50*** + VAT
KSR33 with 20ma loop interface ***£125.00*** + Sound proof enclosure ***£25.00*** + VAT

SOFTY 2

The amazing SOFTY 2. The complete "toolkit" for the open heart software surgeon. Copies, Displays, Emulates ROM, RAM and EPROMS of the 2516, 2532 variety. Many other features include keyboard, UHF modulator, Cassette interface etc. Functions exceed capabilities of units costing 7 times the price! Only ***£169.00*** pp £1.95 *Data sheet on request*

DATA MODEMS

Join the communications revolution with our range of EX TELECOM data modems. Made to most stringent spec and designed to operate for 24 hrs per day. Units are made to the CCITT tone spec. With RS232 i/o levels via a 25 way 'D' skt. Units are sold in a tested and working condition with data. Permission may be required for connection to PO lines.

MODEM 13A compact, async, same size as telephone base. Up to 300 baud, full duplex over 2 wires, but call mode only **£75.00**

MODEM 2B/C Fully fledged, up to 300 baud async, ANSWER & CALL modes, auto answer, auto switching, ideal networks etc. Just 2 wire connection to comms line. **£85.00**

MODEM 20-1 Compact unit for use with PRESTEL or full duplex 2 wire link. 75 baud transmit – 1200 baud receive. Auto answer. **£130.00**

MODEM 20-2 same as 20-1 but 75 baud receive 1200 baud transmit. **£130.00**

MODEM 20-3 Made for data rates up to 1200 baud in full duplex mode over 4 wire circuit or half duplex mode over 2 wires. **£130.00**
Carriage. 13A £4.50. 2B/C & 20 £9.50.

DATA PUMP MODEM compact unit upto 1200 baud full duplex over 4 wires or half duplex over 2 wires. BELL specification with data i/o via RS232 25 way D socket, remote test etc. 240 v operation. Supplied complete with data **£65.00** carr. £4.50.

For more information or details of other types of ex. stock modems contact sales office

SPECIAL MODEM OFFER

EX TELECOM. Direct connect. 2 wire, European standard, 75/1200 baud data modems. Normally priced at £140.00, we have a limited quantity of guaranteed working, but cosmetically defective (ie scratches and scuffs on panels etc.) units at a super low price of only ***£49.95***. Modems are made to the highest standard and conform to the CCITT tone spec. Ideal for **MICRONET, PRESTEL** or **DISTEL's** forthcoming high speed ports. Standard RS232 data i/o via 25 way D skt. With data.
MODEM 2A Early version of modem 2B/C 300 baud full duplex, send-receive, auto answer. RS232 i/o. With data but untested. End of line clearance. **Only *£35.00***. Supplied complete with data. Carriage & Ins. £9.50

8" WINCHESTER price SLASH

S100 Bus 19 Mb. Subsystem. A cancelled order and change of policy by a major British disk drive manufacturer enables us to offer you 'last year's model' at a plug in and ready to go SUPER LOW PRICE. Our own custom controller pugs direct into the S100 bus and wi l control 2 disk drives, offering a total storage of OVER 36 Mbs! and at data transfer rates in excess of 7 Mb/sec seeing is believing!! Supplied complete with user configurable BIOS etc. Save a fortune, Limited quantity only.

3100 19 Mb. Disk drive	***£499.00***	**PSU unit**	***£165.00***
CD1100 controller & BIOS	***£345.00***	**PSU extension cable**	***£9.95***
Full tech Manual	***£20.00***		

Special SUBSYSTEM prices. 1 x 3100 disk + PSU + Controller ***£799.00***
or 2 x 3100 disks + 2 PSU + Controller ***£1295.00***
All prices + VAT and carriage. 90 day guarantee. Data on request.

SEMICONDUCTOR 'GRAB BAGS'

Mixed Semis amazing value contents include transistors, digital, linear, I.C.'s triacs, diodes, bridge recs., etc. etc. All devices guaranteed brand new full spec. with manufacturer's markings, fully guaranteed. 50+ ***£2.95*** 100+ ***£5.15***.
TTL 74 Series A gigantic purchase of an "across the board" range of 74 TTL series I.C.'s enables us to offer 100+ mixed "mostly TTL" grab bags at a price which two or three chips in the bag would nnormally cost to buy. Fully guaranteed all I.C.'s full spec. 100+ ***£6.90*** 200+ ***£12.30*** 300+ ***£19.50***

CALLING DEC USERS

Brand new and boxed

RSX 11M 3.2 Documentation kits, fill 3 feet of your bookshelf! Under half price only ***£120.00*** carr. £6.50 0 vat on manuals.
DEC MSV11-DD 32k x 16 bit RAM ***£195.00***
We are always keen to buy all types of used or surplus DEC equipment.

ALL PRICES PLUS VAT

All prices quoted are for U.K. Mainland, paid cash with order in Pounds Stirling PLUS VAT. Minimum order value ***£2.00***, Minimum Credit Card order ***£10.00***. Minimum BONA FIDE account orders from Government depts., Schools, Universities and established companies ***£20.00*** Where post and packing not indicated please ADD **60p + VAT** Warehouse open Mon-Fri 9.30 — 5.30. Sat. 10.15 — 5.30. We reserve the right to change prices and specifications without notice. Trade, Bulk and Export enquiries welcome.

DISPLAY -ELECTRONICS-

32 Biggin Way, Upper Norwood, London SE19 3XF
Telephone 01-679 4414 Telex 27924

WW – 068 FOR FURTHER DETAILS

www.americanradiohistory.com

B. BAMBER ELECTRONICS

Rank Pullin Airport Weapon Detector Type 3 Walk-through Cabinet. Complete and good working order. **£150 plus VAT.**
Marconi HF Spectrum Analyser Type OA1094A/S complete with Frequency Convertor Type TM644B and mounted on trolley, 0-30 MHz **£90 plus VAT.**
Systron Donner Spectrum Analyser Model 805 200 Hz – 1.6 MHz. **POA.**
Marconi AM Signal Generator Type TF 801D/8S 10 – 485 MHz, **£95 plus VAT.**
Tektronix Oscilloscope Type RM45A Rack Mount mainframes, **£50 plus VAT.**
Tektronix Oscilloscope Type 551 Mainframes with Power Unit, **£75 plus VAT.**
Tektronix Oscilloscope Type 555 Mainframes with Power Unit, **£85 plus VAT**
Tektronix Sampling Oscilloscope Type 661, fitted with 4S1 plug-in, **£120 plus VAT.**
Tektronix Plug-In Units Type B, G, H, K, L. **£25 each plus VAT.**
Avo Transistor Tester Type 2 with Battery and Mains Power Units, **£30 plus VAT.**
Solartron Oscilloscope Type CD 1642.
Solatron Oscilloscope Type CD 1014.3.
Telequipment Oscilloscope Type D 61.
Telequipment Oscilloscope Type D 43 R.
Solartron RC Oscillator Type CD 1004 10Hz – 1 MHz. **£25 plus VAT.**
Advance Oscilloscope Type OS 2100 DC – 30 MHz. **£185 plus VAT.**
Radiosonde RS 21 Meteorological Balloon Transmitter with Water Activated Battery. **£5 each plus VAT.**
Pye Industrial pH Monitor Model 539 complete with Technical Manual, **£30 plus VAT.**
Marconi AM/FM Signal Generator Type TF 995A/5, **£250 plus VAT.**
Charles Austin Two-Stage Air Pump Type F65 DER, complete with pressure regulator, 240 vac., chassis mounted with hoses, etc., brand new and boxed, **£45 plus £5 p.p. plus VAT.**
Tektronix Square Wave Generator Type 107 **£25 plus £5 p.p. plus VAT.**
Rohde & Schwarz A.F. Wave Analyzer Type BN 48302 **£45 plus £15 p.p. plus VAT.**
Rohde & Schwarz Enograph – G Type BN1198/25 **£60 plus £15 p.p. plus VAT.**

Pye Europa MF5FM High Band Sets, ideal for 2 M. 5 watt output 6 Ch, complete but less mike and cradle with circuit diagrams, **£60 each plus VAT.**
Pye Reporter MF6 AM High Band Sets, single Ch, complete but less speaker with circuit diagrams, **£60 plus VAT.**
Pye Motafone MF5AM Mid band 6 Ch, good condition with circuit diagram, **£15 plus VAT.**
Pye Westminster W15AMD Mid Band Single Ch, complete but less speaker, mike and cradle, **£45 plus VAT.**
Pye Westminster W15AMD Low and High Band Sets, complete but less speaker, mike and cradle, **£50 plus VAT.**
Pye Westminster W30AM Low Band Sets, boot mounted, 30 W output, complete but less speaker, mike and leads, **£25 plus VAT.**
Pye Olympic M201 AM High Band, complete but less mike, speaker and cradle. With circuit diagrams. **£40 plus VAT.**
Pye Cambridge AM10D Low Band, few only **£15 plus VAT.**
Pye Cambridge AM10B High Band, few only, **£10 plus VAT.**
Pye Base Station F27 Low Band, **£40 plus VAT.**
Pye Base Station F30 High Band, **£180 plus VAT.**
Pye Base Station F401 High Band, **£220 plus VAT.**
Pye Base Station F9U UHF. Remote. **£90 plus VAT.**
Pye RTC Controller units for remotely controlling VHF and UHF fixed station radio telephones over land lines. **£10 plus VAT.**
Pye PC1 Radiotelephone controller, good condition, **£50 plus VAT.**
Pye Base Station Tx Type T406 100 W Low Band FM. **£150 plus VAT.**
Pye Base Station Tx Type T100 100W FM 'G' Band 38.6-50 MHz, ideal for 6 M. New condition. **£100 plus VAT.**
Pye Pocketfone Type PF5, UHF 'T' Band, complete with battery, good condition, **£45 plus VAT.**
Pye Pocketfone PF5 Battery Charger Type BC16A, **£25 plus VAT.**
Pye Pocketfone PF1 UHF Receiver, 440-470 MHz, single channel, int. speaker and aerial. Supplied complete with rechargeable battery and service manual. **£6 each plus £1 p.p. plus VAT.**
Ni-Cad Batteries for Pye PF1 rx, used but good condition, **£2 each**, PF1 tx Batteries, **£3 each plus VAT.**

PLEASE NOTE: All sets are sold less crystals unless otherwise stated. Carriage on RT equipment – Mobiles £2 each. Base stations £15 each. Red Star available at cost.

SEMICONDUCTORS & VALVES p.p. 50p per order. **PLEASE ADD VAT.** 1N4148 10 for 25p, 741 4 for **£1**, 555 4 for **£1**, Z80-P10 **£1.85**, Z80-CTC **£1.85**, BC108 4 for **50p**, BC109 4 for **50p**, BC113 4 for **50p**, BC148 4 for **50p**, BC149 4 for **50p**.
QQV03 – 10 ex-equip. **£1.20**, QQZ03 – 10 new **£2.50**, QQV03 – 20a ex-equip **£5**, QQV06 – 40a **£15**, QQZ06 – 40a ex-equip, **£10**.
VIDICON SCAN SOILS 1" Transistor type but no details, complete with vidicon base. **£3.50 each plus 50p p.p. plus VAT.**
Mains isolating transformer, 500VA 240V input, 240V C.T. output, noused in metal box. **£15 each plus £6 p.p. plus VAT.**
Mains isolating transformer, 240V tapped input, 240V 3 amp, plus 12V 0.5 amp output, **£20 each plus £6 p.p. plus VAT.**
Garrard Car Cassette Player Mechanisms, 12 V motor, stereo head, brand new, **£2.50 each plus 50p p.p. plus VAT.**
Cigar Lighter Plug with lead, **£1 each p.p. plus VAT.**
IC Test Clips, 28 way and 40 way, gold plated, **£2 each plus 30p p.p. plus VAT.**
60 amp Alternator and Generator Noise Filters for use in vehicles, **£1 each plus 50p p.p. plus VAT.**
Computer Grade Electrolytic Capacitors, screw terminals, 25000 mfd., 33 volt, brand new, **£1 each plus 50p. p.p. plus VAT.**
Mains Transformers 220 v Pri. 36 v @ 1.5 amp. Sec. **£1 each plus 50p p.p. plus VAT.**
BASF Chromdioxid Video Cassette Tape for use with Philips N1500/1700 VCR. LVC30+5, 36 min. long play. **£5 each plus 50p. p.p. plus VAT.**
Mullard Vari-Cap Tuners Type ELC2003, UHF only, removed from brand new TV sets. **£3.50 plus 5p. p.p. plus VAT.**
2N3055 Transistors, Brand New, 4 for £1 plus 20p, p.p. plus VAT.
Beryllium Block Mounts for CCS1 valves. Brand new and Boxed, **£10 each plus 50p. p.p. plus VAT.**

Good secondhand equipment always wanted for cash

All prices quoted exclude p/p and VAT unless otherwise stated

BARCLAYCARD VISA

5 STATION ROAD, LITTLEPORT, CAMBS CB6 1QE
PHONE: ELY (0353) 860185

Access

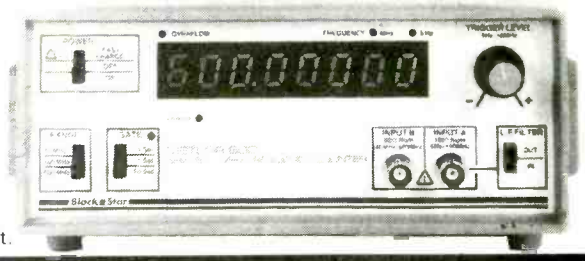
WW – 062 FOR FURTHER DETAILS

FREQUENCY COUNTERS

HIGH PERFORMANCE
HIGH RELIABILITY
LOW COST

The brand new Meteor series of 8-digit Frequency Counters offer the lowest cost professional performance available anywhere.

- ★ Measuring typically 2Hz – 1.2GHz
- ★ Sensitivity <50mV at 1GHz
- ★ Setability 0.5ppm
- ★ High Accuracy
- ★ 3 Gate Times
- ★ Low Pass Filter
- ★ Battery or Mains
- ★ Factory Calibrated
- ★ 1-Year Guarantee
- ★ 0.5" easy to read L.E.D. Display



PRICES (Inc. adaptor/charger, P & P and VAT)

METEOR 100	(100MHz)	£104.07
METEOR 600	(600MHz)	£133.97
METEOR 1000	(1GHz)	£184.57

Illustrated colour brochure with technical specification and prices available on request.

Designed and manufactured in Britain

Black Star

BLACK STAR LTD. 9A Crown Street, St.Ives, Huntingdon, Cambs. PE17 4EB, England.
Tel: (0480) 62440 Telex: 32339

WW – 041 FOR FURTHER DETAILS

EASIBINDERS *Quick, neat and easy!*

It's so easy and tidy with the Easibind binder to file your copies away. Each binder is designed to hold six issues and is attractively bound and blocked with the WIRELESS WORLD logo.
Price U.K. £4.30 including postage, packing and V.A.T.
Overseas orders add 35p per binder.
Nat. Giro No. 5157552.
Please allow 3/4 weeks for fulfilment of order.
Payment by ACCESS/BARCLAYCARD/VISA. Send coupon below detailing credit card no. and signature.
Why not place your order now? Send the completed coupon below with remittance payable to:
Easibind, 42 Hoxton Square, London N1 6NS

Order Form WIRELESS WORLD

I enclose P.O./cheque value.....for.....binders
Years required.....
BLOCK LETTERS PLEASE
Name.....
Address.....
.....
Date.....Registration No. 735718

METAL FILM RESISTORS

100R	1k	10k	100k
110R	1k1	11k	110k
120R	1k2	12k	120k
130R	1k3	13k	130k
150R	1k5	15k	150k
160R	1k6	16k	160k
180R	1k8	18k	180k
200R	2k	20k	200k
220R	2k2	22k	220k
240R	2k4	24k	240k
270R	2k7	27k	270k
300R	3k	30k	–
330R	3k3	33k	330k
360R	3k6	36k	–
390R	3k9	39k	–
430R	4k3	43k	–
470R	4k7	47k	470k
510R	5k1	51k	–
560R	5k6	56k	560k
620R	6k2	62k	–
680R	6k8	68k	680k
750R	7k5	75k	–
820R	8k2	82k	820k
910R	9k1	91k	1M

¼ Watt, 1% tolerance, 3p each. 89 Values, E24, see left. Minimum order £20. Minimum 10 pcs per value. VAT, P&P incl.

SPECIAL OFFER
10 pcs of each value, 890 pcs
£25.30

SPECIAL 'POP' PACK
100 pcs: 100R, 1K, 4K7, 10K, 47K, 100K, 1M. 50 pcs: 330R, 470R, 1K5, 2K2, 3K3, 22K. Total 1000 pcs. £28.50.

One of each pack £50 only

ORION SCIENTIFIC LTD - 16 Orange Street - London WC2H 7ED

WW – 063 FOR FURTHER DETAILS

www.americanradiohistory.com

Appointments

Advertisements accepted up to 12 noon Thursday, October 4th, for November issue, subject to space available.

DISPLAYED APPOINTMENTS VACANT: £17 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £3.50 per line, minimum £25 (prepayable).
BOX NUMBERS: £5 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS).
PHONE: IAN FAUX, 01-661 3033 (DIRECT LINE)
Cheques and Postal Orders payable to BUSINESS PRESS INTERNATIONAL LTD. and crossed.

ecm

ALWAYS AHEAD WITH THE BEST!

£7,000-£20,000

★ **Where does your interest lie:** Communications; Computers; Weapons; Radar; Sonar; Data-Comms; Signal Processing; Medical; Telemetry; Simulation; Satcom; Local Area Nets; ATE?
★ **Experienced in:** Microprocessor Hardware or Software; Digital and Analogue circu try; RF and Microwave techniques?
★ **There are hundreds of opportunities in:** Design; Test; Sales and Service for Engineers and Managers
★ Act now: Just dial 100 and ask for **FREEPHONE JOBLINE** or send your C.V. (no stamp needed) to:

ELECTRONIC COMPUTER AND MANAGEMENT APPOINTMENTS LIMITED
Freepost, Barkway, Royston, Herts SG8 8BR
(1926)

THE UNIVERSITY OF SHEFFIELD
Audio Visual & Television Centre

SENIOR TELEVISION ENGINEER

Applications are invited for the above post. The successful applicant will take charge of all engineering aspects of the Centre's work, including planning and development, studio and mobile operations and supervision of the technical staff. Applicants should preferably be graduates or have comparable qualifications in electronic engineering and wide experience in broadcasting, industrial or educational television. Initial salary on Grade II for Other Related Staff £11,160-£14,125 a year according to qualifications and experience. Tenable for two years in the first instance. Particulars from the Registrar and Secretary (Staffing), the University, Sheffield S10 2TN to whom applications (5 copies), including the names of three referees, should be sent by 30 September 1983. Quote ref. R898/BH.

(2266)

CAPITAL APPOINTMENTS LTD

THE UK's No. 1 ELECTRONICS AGENCY

If you have HNC/TEC or higher qualifications and are looking for a job in design, test, customer service, technical sales or similar fields:

Telephone now for our free jobs list
We have vacancies in all areas of the UK
Salaries to £15,000 pa

01-637 5551 or 01-636 9659
(24 hours)

Or if you prefer send a FULL CV to:

CAPITAL APPOINTMENTS LTD
29-30 WINDMILL STREET, LONDON W1P 1HG

(291)

SENIOR DEVELOPMENT ENGINEER

Location: West London

An appointment exists within a long established electronic data capture company for a senior development engineer.

The main duties associated with this appointment are:

★ Development of microprocessor based data capture equipment.
★ Development of customised interfaces.
★ Customer liaison.

The successful applicant would probably be qualified to HNC level, and have at least three years' experience in the electronic industry, preferably in data processor type equipment, and have experience of microprocessors and data communications interfaces.

Normal large company benefits + company car.

Salary commensurate with experience.

Apply to Box No. 2282

ELECTRONICS TECHNICIAN

required for workshop and field servicing of hospital and medical laboratory equipment

Qualifications to tec (HC) or equivalent. Some experience in a related area preferred. Some UK and European travel expected

Salary £6,000+ (negotiable). Car provided

Write with details of experience and qualifications to:

Mr Ray Morrisey
Electra Med
13 Woodlands Park
Gerton
Cambridge CB3 0QB

(2269)

SURREY COUNTY COUNCIL
Guildford County College of Technology invite applications for the following vacancy:
Department of Science and Electrotechnology

SENIOR TECHNICIAN in COMPUTER TECHNOLOGY

£6,264-£7,005/£7,191-£7,896
plus £270 Surrey Allowance

Suitably qualified person required to service computer equipment, with an emphasis on microprocessor development.

Application forms and further details from the Committee Clerk, Guildford County College of Technology, Stoke Park, Guildford, Surrey GU1 1EZ, on receipt of SAE. (Tel: Guildford 31251)

Closing date: Friday 14th October 1983
(Re-advertisement)

(2268)

PHOTOSTAFF

The Photography, A/V, Film and Video Agency has vacancies for:

VIDEO ENGINEERS. To service, repair and maintain domestic, industrial and broadcast equipment. Salaries from £6,000 to £18,000+. U.K. and overseas.

RESEARCH & DEVELOPMENT. Experienced Degree or HND level Engineers. Opportunities exist for project leaders, technical assistants, etc., in electronics, electromechanics and computing.

PHOTOSTAFF, 133 Oxford Street, London W1
Tel. 01-439 1821

www.americanradiohistory.com

Appointments

CUT THIS OUT!

Clip this advert and you can stop hunting for your next appointment. We have a wide selection of the best appointments in Digital, Analogue, RF, Microwave, Micro processor, Computer, Data Comms and Medical Electronics and we're here to serve *your* interests.

Call us now for posts in Design, Sales, Applications or Field Service, at all levels from £6,000-£16,000.

Technomark
Engineering & Technical Recruitment
11 Westbourne Grove, London W2. Tel: 01-229 9239

1935

PIONEER

require

A SAFETY/TECHNICAL CO-ORDINATOR

Pioneer High Fidelity (GB) Limited is a very successful and expanding company in the electronic consumer industry. We market a wide range of Hi Fi, Car Audio and Video products.
A vacancy now exists in our Technical Department for a Safety/Technical Co-ordinator at our new premises in Greenford, Middlesex.
The job entails the submission of new products to B.E.A.B. for approval, liasing with our factories in Japan and with the United Kingdom Safety Authorities and the writing of technical service bulletins for our dealers and authorised service centres.
The successful applicant should be fully conversant with BS-415 safety standards, applicable to domestic electrical equipment, and should have had at least two years' experience in this field.
He/she should be qualified to H.N.C. or equivalent standard in electronics and preferably with at least three years' experience in domestic HiFi and/or Video equipment. Some experience in technical writing is also essential.
Benefits include competitive salary, four weeks' holiday, subsidised restaurant, contributory pension scheme and private health cover.

For further information or an application form, please contact:
Mrs C. A. Burridge, Pioneer High Fidelity (GB) Limited
Field Way, Greenford, Middx. UB6 8UZ. Tel: 01-575 5757

(2196)

LABORATORY TECHNICIANS

We have vacancies for Laboratory Technicians at senior and junior level at our Equipment Department, based at Chiswick. Duties include the testing of newly manufactured broadcast equipment and involve work on sound, television, radio-frequency and digital equipment.

Technicians should possess, or be studying for a TEC or HTEC certificate in electronics, and have at least one year's relevant experience. Salary is in the range £6346 to £7615.

Applicants with less experience may be considered for junior posts at a lower salary.

Requests for application forms to **Engineering Recruitment, BBC, P.O. Box No. 2BL, London W1A 2BL. Quote reference 83.E.4099/WW.**

BBC

We are an equal opportunities employer

PLYMOUTH HEALTH AUTHORITY

Department of Medical Physics and Biomedical Engineering

ELECTRONICS TECHNICIAN

required for interesting post in medical electronics. The person appointed will be a member of a team of nine in a well-equipped and expanding Department. He/she will be responsible to a graduate electronics engineer for maintenance and development of a wide range of patient-orientated equipment situated in Hospitals and Health Centres throughout the Plymouth Health District.

Hospital experience is not essential, as further training will be given. HNC, ONC, City and Guilds Final Certificate or equivalent qualification is required. The work involves occasional travel and necessitates a current driving licence. There is a requirement to participate in a scheme to provide out of hours emergency cover. The current salary scale is £5,171 rising to £6,798.

Further information is available from Mr A. C. Dawson, Chief Technician, telephone Plymouth (0752) 834276.

Application forms are available from the Personnel Officer, Unit Personnel Dept. PGH No. 1, Belvedere, Greenbank Road, Plymouth PL4 7JN. Please enclose a stanped addressed envelope.

Closing date for return of application forms: 21st October, 1983.

(2260)

Proposal Support Manager

£10,000 + generous bonus
Surrey

Granger Associates are a leading company in the design, manufacture and marketing of communications equipment for overseas markets. Our products are marketed extensively to both major industrial nations and to developing countries and we are now looking to strengthen further our commercial expertise by appointing a Proposal Support Manager.

Based at our Sales Headquarters in Weybridge, Surrey, you'll provide vital support to the international sales team in the preparation of systems and proposal documentation for all our communications products marketed to Europe, Africa and the Middle East, with particular emphasis being placed upon HF systems.

In addition to sound relevant experience gained within an electronics engineering environment, you will need to be a good communicator at all levels with the ability to interpret Government, Military and commercial specifications, and work effectively under pressure. Knowledge of a foreign language would be a distinct advantage.

Please write in the first instance with full c.v. to Mrs L. Tabb, Granger Associates Ltd., 1 Brooklands Road, Weybridge, Surrey KT13 0SD.

Granger Associates Ltd.

www.americanradiohistory.com

GRADUATE STATUS ENGINEERS AND SCIENTISTS

COME TO HIGH-TECH COUNTRY

IN COMMUNICATIONS R&D

Hanslope in Buckinghamshire is, we admit, an unlikely backdrop for high technology research and development.

Yet a mere stone's throw away from this delightful rural village the men and women at HM Government Communications Centre are applying the very latest ideas in electronics to the development of sophisticated communications systems and installations, designed to meet special Government needs both at home and overseas.

For graduates and near graduates with real ability and a genuine passion for creative electronics design (the kind of enthusiasm that may already have prompted you to design and build your own communications equipment), this is a superb career environment.

Technically challenging projects cover a wide range of interests including radio (HF to microwave, advanced modulation, propagation studies and micro-circuitry applications); acoustics; magnetics; signal analysis; systems engineering.

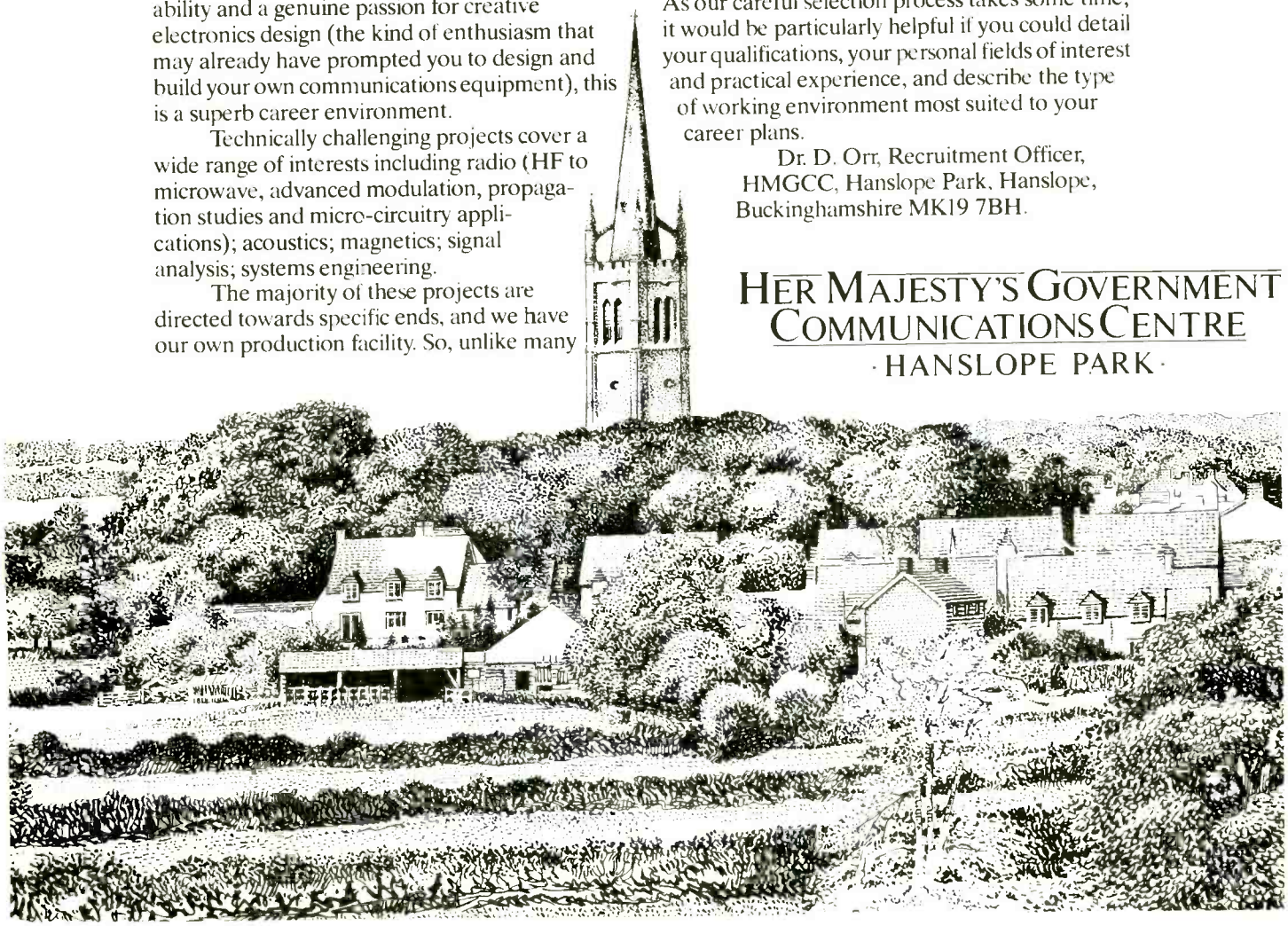
The majority of these projects are directed towards specific ends, and we have our own production facility. So, unlike many other R&D establishments, HMGCC offers you the satisfaction of seeing your work right through from conception to manufacture.

With such a broad spectrum of work and training facilities at your disposal, HMGCC is an ideal environment in which to develop the potential you've gained by studying an electronics-biased course. What's more, we think you'll find the working conditions and location very much to your liking.

Please write to us for further details on the work and the remunerations offered at the Centre. As our careful selection process takes some time, it would be particularly helpful if you could detail your qualifications, your personal fields of interest and practical experience, and describe the type of working environment most suited to your career plans.

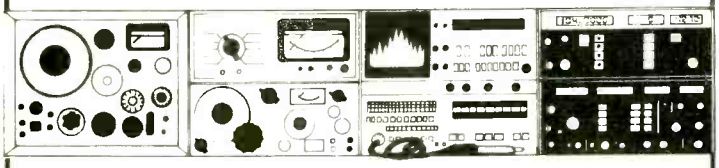
Dr. D. Orr, Recruitment Officer,
HMGCC, Hanslope Park, Hanslope,
Buckinghamshire MK19 7BH.

HER MAJESTY'S GOVERNMENT
COMMUNICATIONS CENTRE
· HANSLOPE PARK ·



www.americanradiohistory.com

Test & Calibration Engineers



Having introduced an extended new product range, many of which are microprocessor based, Marconi Instruments has once again confirmed itself as Europe's leading manufacturer of sophisticated test and measurement systems. Our products are selling throughout the world and we are naturally developing further new and innovative designs.

A key role in our organisation is that of our Luton based Service Division, where a group of Technicians satisfy a very wide range of customer needs in the repair and calibration of test equipment.

When you join our team you will quickly become individually responsible for work assignments involving many different kinds of propriety products.

Prospects are excellent. The Division is part of a large company with its main Instrument Design/Manufacturing Base at St. Albans, a Microwave Plant at Stevenage and a further substantial Design Manufacturing Group at Donibristle in Scotland. The Company is proud of its policy of promoting men and women from within, as future Salesmen, Managers and Engineers.

Salaries, which are dependent upon experience and ability are excellent and regular overtime is normally available. Progress for competent engineers and technicians can be rapid. Relocation assistance is available in approved cases. Special consideration is given to 'ex-forces' personnel.

Whatever your level of experience we would like to hear from you. Cut out the coupon and send it to John Prodger, Recruitment Manager, Marconi Instruments Limited, FREEPOST, St. Albans AL4 0BR. Tel: (0727) 59292.

Name Age

Address

Tel. No.

Years Experience

Present Salary: £6,000 £7,000 £8,000 Over

£7,000 £8,000 £9,000 £9,000

Qualifications

Present Job

(2143)

marconi instruments

Marconi

ELECTRONIC MAINTENANCE ENGINEER

Yorkshire Television, one of the five major Independent Television Companies, has established a worldwide reputation for producing quality award-winning programmes. Each week, over 100 hours of programmes are transmitted to 6 million viewers in Yorkshire, Lincolnshire and Derbyshire.

The Industry Code of Practice sets exacting quality standards for broadcast television. To meet these stringent performance parameters, the Electronic Maintenance team follows a comprehensive policy of routine maintenance, inspection, examination and measurement of the complex electronic systems in the Leeds studio facility.

Through internal promotion, an opportunity has arisen to join the Electronic Maintenance team. Applicants should be qualified to a minimum of HNC level or equivalent in Electronic Engineering. Experience of working, using advanced test equipment, on broadcast electronic systems, either with a television company or an equipment manufacturer is essential.

Starting salary will be in a range up to £12,500 depending on qualifications and experience, plus overtime payments.

Applications in writing to:
The Personnel Officer (Recruitment)
Yorkshire Television Limited
The Television Centre, Leeds LS3 1JS

YORKSHIRE TELEVISION

ELECTRONIC INSTRUMENT SYSTEMS TECHNICIANS

Sartorius Instruments is a world leader in electronic weighing in the analytical, research, quality assurance and allied industries. The product range is expanding further into the industrial system's market and personnel are required to supplement our already established Field Service team.

Successful applications will service and install our computerised systems nationwide. Primary responsibilities will be problem solving of Sartorius equipment and liaison production and the customer.

Education to a suitable allied qualification i.e. C&G/TEC – Electronics is preferred. A successful trouble shooting ability in electronics is essential with a knowledge of basic computer programming.

On appointment you will spend three weeks training in our workshop in Belmont followed by suitable training at our parent company factory in West Germany, when available. Initially the job will require a large proportion of time to be spent at our in-house service centre at Belmont, Surrey.

Candidates must be in possession of a current driving licence and be prepared for nationwide travel. A company car is provided.

In addition to the above vacancies technicians are required for certain areas on general electronic and mechanical balance maintenance.

If you would like to receive more information or apply for a position, please write giving brief career details to the Service Co-ordinator, Sartorius Instruments Limited, 18 Avenue Road, Belmont, Surrey.

(2267)

www.americanradiohistory.com

"Excellence takes some maintaining"

Television Recording requires Electronics Engineers to train in Broadcast Engineering, to support an expanding Video Tape and Telecine Operation, which includes complex digital and analogue equipment.

Applicants need not initially possess an in-depth knowledge of Television Engineering, as full training will be given, but previous academic training must be supported by enthusiasm for practical engineering.

After training, applicants will progress to work involving all aspects of Television Recording, including in-depth servicing, acceptance of equipment, design of modifications, and technical investigations.

These challenging posts offer excellent promotional prospects for the self-motivated and committed engineer capable of working at the forefront of today's technology.

Salaries range from £8,129 to £9,200–this includes an allowance for shift working. A higher salary will be considered in exceptional circumstances.

Qualifications required are, a Degree in Engineering, HND, HNC, Full C & G.

For further information please write, with details of your academic and work experience, to **Bob Neal, BBC, P.O. Box 2 BL, London W1A 2BL.**

Please quote ref: 83.E.4055.

We are an equal opportunities employer.

BBC

television recording

WW/219

www.americanradiohistory.com

Head of Antennae Design Group

In "Survivability" technology MEL, the Electronic Systems Development Division of the Philips U.K. Group of Companies, have been pioneers for over 30 years. Since the earliest days of Electronic Warfare, we have been applying our technical expertise and in-depth understanding of military and naval needs to the development of systems which detect, analyse and counter enemy threats. Systems which include ESM, ECM and ECCM that are more than a match for the growing sophistication of land-based, airborne or shipborne radar and air or surface launched homing missiles.

A key in-house consultancy and design service is that of the Antennae Design Group who ensure the application of the most advanced technology in the design, production and utilisation of antennae systems for many of our projects.

Applicants for the position of Head of this key activity must offer an appropriate professional engineering background and proven ability in technical leadership at least to the level of 2 i/c within a similar activity. The successful candidate will report directly to the Technical Manager and will carry "bottom line" responsibility for the performance of the Group.

Salary and other conditions will be attractive. Assistance with relocation is available, if required. Please write, in full confidence, quoting reference WW9 to:
Mr. L. B. Staunton, Personnel Manager, MEL, Manor Royal, Crawley, Sussex.

MEL

(2285)

Electronic Engineers – What you want, where you want!

TJB Electrotechnical Personnel Services is a specialised appointments service for electrical and electronic engineers. We have clients throughout the UK who urgently need technical staff at all levels from Junior Technician to Senior Management. Vacancies exist in all branches of electronics and allied disciplines - right through from design to marketing - at salary levels from around £5000-£15000.

If you wish to make the most of your qualifications and experience and move another rung or two up the ladder we will be pleased to help you. All applications are treated in strict confidence and there is no danger of your present employer (or other companies you specify) being made aware of your application.

TJB ELECTROTECHNICAL PERSONNEL SERVICES,
12 Mount Ephraim,
Tunbridge Wells,
Kent. TN4 8AS.

Tel: 0892 39388

TJB

Please send me a TJB Appointments Registration form:

Name .....

Address .....

.....

(861)

BORED ?

Then change your job!

1) Video/TV Equipment
Field Service Engineers required with experience of analogue/digital/computer based equipment. £9-£10,000 – Hants.

2) Microprocessor-based Control Systems
Commissioning/Servicing Engineers required. To £8,500 – Sussex.

3) Computer Peripherals
Service Engineers to repair complex PCBs for terminals, printers, disc drives, etc. C. £8,000 – Surrey.

4) Video/CC TV/Audio Equipment
Installation/Service Engineers needed with experience of audio/video systems. C. £9,000 – Surrey.

5) Service Personnel
(RAF, RN, Army)
We have many clients interested in employing ex-service fitters and technicians at sites throughout the UK. Phone for details.

6) £500 per week
We are paying very high rates for contract design and test engineers who have a background in RF, MICROWAVE, DIGITAL, ANALOGUE or SOFTWARE, at sites throughout the UK.

Hundreds of other Electronic and Computer Vacancies to £12,500

Phone or write:
Roger Howard, C.Eng., M.I.E.E., M.I.E.R.E.

CLIVEDEN CONSULTANTS
87 St. Leonard's Road, Windsor, Berks.
Windsor (07535) 58022 (5 lines)

(1640)

CLIVEDEN

LOGEX ELECTRONICS RECRUITMENT

Specialists in Field & Customer Engineering appointments, all locations and disciplines

Logex House, Burleigh, Stroud
Gloucestershire GL5 2PW
0453 883264 & 01-290 0267
(24 hours)

www.americanradiohistory.com

CUSTOMER ENGINEER

North London-based
to £9,100 + car + extensive benefits

Do you have at least a couple of years' electronics field service experience backed by a relevant HNC (or equivalent)? If so, you could be just the person we seek to service our sophisticated range of medical electronic equipment in the North London area.

As the dominant leader in the UK instrumentation market, we can offer you a comprehensive programme of induction and on-going training. There are outstanding career development prospects in this very successful high-technology company. An attractive salary is backed by profit-sharing and a share-purchase scheme among the wide range of company benefits.

Aged at least in your mid-20s, and preferably living on or within reach of the territory, you must have the strong personal presence to succeed in a demanding customer-contact environment in addition to a high level of technical capability. Previous experience of hospital markets and equipment, whilst an advantage, is not essential.

Move up to a more satisfying – and more rewarding – field service challenge with the top name in electronic measurement systems. Call Andrew Webb for more information and an application form on 0344 773100. Or write to him enclosing your full personal and career details at Hewlett-Packard Limited, Nine Mile Ride, Easthampstead, Wokingham, Berkshire RG11 3LL.

HEWLETT PACKARD

World Leading Telecoms Products

RF ENGINEERING

£12,000 to £15,000 **Home Counties**

Our client has precipitated many firsts in the history of communications technology and currently offers the most advanced business communications systems available in the market. The need to stay ahead in a fast moving technological world demands the highest calibre of engineers available, coupled with extensive use of the latest design aids. The current design of the next generation system has created the opportunity for a Project Engineer and a Senior Engineer to control the complete engineering aspect of this project.

The ideal candidates will be:-
- qualified to degree or equivalent in electronics or telecommunications
- experienced in analog design up to and including VHF
- currently employed within radio or communications related industries

The responsibilities range from involvement in the initial design of specifications, through all the trouble-shooting and problem solving aspects of the concept to prototype building and successful quantity production.

These opportunities offer a dedicated professional environment with an unrivalled range of support resources throughout the group. Career development is excellent within one of the Company's most successful and fastest expanding departments. The complete package, which will include relocation expenses where appropriate, is highly attractive to the successful candidate.

For an initial and confidential discussion please call Bob Archibold on Newbury (0635) 33445 quoting reference D/111 or write in strict confidence to: –

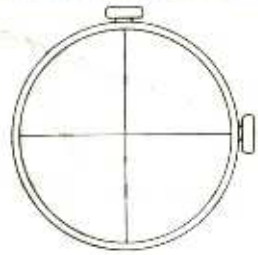
ARC

ARCHIBOLD RAE CONSULTANTS LIMITED,
(High Technology Search & Selection),
7, London Road, Newbury, Berkshire RG13 1JL.
Tel: Newbury (0635) 33445.

(2255)

www.americanradiohistory.com

THE HUNT IS ON—FOR ELECTRONICS ENGINEERS WHO HAVE SET THEIR SIGHTS HIGH



The current Jaguar cars represent the epitome of mechanical engineering excellence, but to maintain this lead through the remainder of this century will require a complementary standard in vehicle electronics. We are therefore seeking to recruit a specialist electronics team whose brief will be to identify and solve problems in the application of microprocessors and computers to cars from system design through to manufacture and service.

The formal qualifications sought will be a degree in electronics or related subject, with both hardware and software experience. Applications from multi-disciplinary engineers who have experience in other relevant areas such as engines, instrumentation, transducers, CAD, reliability engineering or computer modelling will be viewed with particular favour.

The salary and benefits package including relocation where appropriate, reflects the key nature of these positions.

To put your career on target write in confidence giving full career details and current salary to:

A. R. Chapman
Manager, Organisation & Personnel Planning
Jaguar Cars Limited
Browns Lane, Allesley, Coventry CV5 9DT

We are an equal opportunity employer

JAGUAR

(2256)

---

incomtel ltd.

INSTALLATION COMMISSIONING

Due to rigid expansion, we require an installation and commissioning engineer to work principally on overseas projects. Experience in two or more of the following is essential:

Studios/HF/MF/VHF/TV. Knowledge of a foreign language would be an advantage.

An attractive salary and benefits package will be offered to the successful applicant.

Please send c.v. or résumé to:
The Director of Operations
INCOMTEL LTD, 225 Goldhawk Road
London W12 8SB. Tel: 01-743 5511

(2258)

UNIVERSITY OF LONDON
Institute of Education

TECHNICIAN

required to organise and run new Advisory and Service Unit containing BBC, 380Z, 480Z, Spectrum and Apple microcomputers. Duties include hardware maintenance, assisting users and designing interfaces between microcomputers and other equipment. Experience in practical applications of digital and analogue electronics to microcomputers and peripheral equipment; knowledge of BASIC, 6502 and Z80 assembler and programming of VIAs also required

Salary within range £8,422-£9,822 inclusive. Appointment for three years initially.

Please contact Mary Griffin, on 636 1500 Extension 254 or at University of London Institute of Education, 20 Bedford Way, London WC1H 0AL for further details and an application form. Closing date 5 October.

(2262)

TOWNLEY EMPORIUM

Bargains for callers
or send for catalogue

ELECTRICAL, ELECTRONIC & MECHANICAL COMPONENTS

Vast range of surplus test equipment; Diodes; Thyristors; Resistors; Terminals; Switches; Relays; Screws; ICs; Tools.

Harehill Street off Burnley Road, Todmorden, Llancs OL14 5JY

(2172)

The Polytechnic of North London

Department of Electronic and Communications Engineering

LABORATORY TECHNICIAN Grade III (Electronics)

Applications are invited for the above post, to assist senior staff in the day-to-day running of the Department's busy laboratories.

The duties involve the construction, modification and repair of experimental chassis working from precise instructions, together with the preparation and setting-up of equipment for class practicals. Some experience with the use and maintenance of oscilloscopes, signal generators and power supplies would also be an advantage.

Qualifications:
OND, ONC, two A levels or Ordinary City and Guilds or equivalent, with three to five years' relevant experience (including training period).

Salary scale:
£5,151-£6,036 plus £1,220 London Weighting.

Application forms and further details from Mr. E. W. Bowman, Departmental Superintendent, Department of Electronic and Communications Engineering, The Polytechnic of North London, Holloway Road N7 8DB.

Closing date for receipt of applications: October 7, 1983. (2280)

INSTALLATION ENGINEER

Electronics engineer required to pre-assemble and install complex sound and lighting systems worldwide. Good electronics knowledge and common sense vital. Applicants should be single, in twenties, and be prepared to travel extensively. Salary up to £10,000 depending on experience.

Ring or write:
Linda Johns 01-741 7241
Bacchus International Discotheque Services
64/66 Glentham Road
London SW13 9JJ

(2243)

GRAND OPPORTUNITY FOR LIGHTING BOFFIN

A neat, company-minded, self-motivated individual interested in working with a team of people shaping the future.

Duties will include Q.A. of Lighting and Audio Musical Products for the music, theatre and rock 'n' roll industry, with some opportunities for design and update work.

A good working knowledge of both analogue and digital techniques is essential, particularly in lighting control application.

PRIMA DONNAS NEED NOT APPLY

Apply in writing with c.v. and current salary directly to:

THE MANAGING DIRECTOR
ROLAND (U.K.) LIMITED
979 GREAT WEST ROAD
BRENTFORD
MIDDLESEX

(2251)

ELECTRONICS TECHNICIAN (Grade V)

required for Department of Biochemistry to be responsible for a wide range of equipment used in teaching and research. Good knowledge of fault finding, together with the ability to design, construct and service apparatus essential. Salary in range £6,279-£7,332 plus £1,220 per annum London Weighting.

Application form from Personnel Officer (Technical Staff FC7), University College London, Gower Street, London WC1E 6BT.

(2259)

INDUSTRIAL VIDEO ENGINEER

With experience in high quality black and white video needed.

Telephone 01-900 0497

(2246)

www.americanradiohistory.com

SITUATIONS VACANT

Satellite Communications

• Spacecraft Systems • Communications Systems • Antenna Design • Radar and Signal Processing • Electronic Circuit Design • Ground Support • RF and Microwave Equipments • Power Supplies • Mechanical, Thermal and Dynamics Design • Assembly, Integration and Test • E.M.C. • Quality Assurance and Reliability

Recently awarded contracts have created a need for immediate expansion of on-site facilities and the design team. Some senior appointments have been filled from within, but there are still opportunities for Engineering Managers and Group Leaders to head up additional teams now being formed.

At Senior Engineer/Engineer levels there are several vacancies in each of the above work areas.

Qualifications required are Degree/HND/HNC in a relevant discipline, plus experience.

Excellent salaries and comprehensive range of benefits are offered, together with relocation assistance if required.

Please complete the coupon below, and send it to:

Jack Burnie, Marconi Space and Defence Systems, Browns Lane, The Airport, Portsmouth, Hants. Tel. Portsmouth 674019.

(All posts are open to both male and female applicants).

Design Engineers

Name _____

Address _____

_____

Age _____ Telephone (Home) _____ (Work) _____

Qualifications _____

I have the following years experience

Spacecraft Systems ☐ RF and Microwave Equipments ☐

Communications Systems ☐ Radar/Signal Processing ☐

Antenna Design ☐ Electronic Circuits (VHF/UHF) ☐ E.M.C. ☐

Structures: Mechanical ☐ Thermal ☐ Dynamics ☐

Assembly, Integration and Test ☐ Ground Support ☐

Power Supplies ☐ Quality Assurance and Reliability ☐ Ref BL 100

Marconi
Space & Defence Systems

Radio & TV Electronic Servicing Instructor

Have you thought of teaching your skill? We have a vacancy for a Radio and TV Electronic Servicing Instructor at Deptford Skillcentre.

To apply you should have a full trade training, be at least 25 years of age, and have five years' practical experience behind you.

The promotion opportunities, pensionable security and self-respect are what only a leading training organisation like ours can offer.

There is a starting salary of £7,062 rising by two annual increments to £8,510 plus £500 Outer London Weighting.

If you think you've got what it takes telephone **Thirza Mathieson on 01-836 1213, ext. 443. Manpower Services Commission, Selkirk House, 166 High Holborn, London WC1V 6PF.**

(2290)

ELECTRONICS ENGINEER

committed to Third World Development

to develop simple solar voltaic products and assist in establishing small scale manufacturing units in **Botswana.**

Practical experience of design and construction of electronic devices essential.

2 year contracts including modest living allowance and flights. Regret no funding for dependants.

Write for details including short c.v. and s.a.e. to: International Voluntary Service, EW2, 53 Regent Road, Leicester LE1 6YL.

WORK FOR PEACE & UNDERSTANDING IVS

BRIGHTON POLYTECHNIC

LEARNING RESOURCES

TECHNICIAN/ PROJECTIONIST

£2,976-£6,135

Technician required to assist in the audio-visual equipment loan service to support teaching at the Moulsecoomb site. Equipment includes colour cameras, video recorders and high-quality sound and film equipment. Applicants should be familiar with audio-visual equipment of this kind, and able to work with a wide range of academic, production and engineering staff. Work will include some first line maintenance.

Further details and application forms are available from the Personnel Officer, Brighton Polytechnic, Moulsecoomb, Brighton BN2 4AT. Tel: Brighton 693655, Ext. 2536. Closing date: September 30, 1983. (2290)

ARTICLES FOR SALE

24 COLUMN PRINTER ONLY £69 EACH (inclusive)

Standard 4-inch 3U mounting; inverted 4 double sized print; single 9V AC or 5V DC power supply; standard centronics interface or serial data; extends only 40mm behind panel.

For further details contact:
Benwick Electronics
9 Doddington Road, Benwick
nr March, Cambs, PE15 0UX
Telephone: Benwick (035477) 471

LINSLEY HOOD DESIGNS

75Watt and 100W amps
Audio Signal Generators

75Watt amp p.c.b. £2.30
100Watt Mosfet p.c.b. £4.00

p&p 50p

S.A.E. for leaflets

TELERADIO ELECTRONICS
325 Fore Street, London N9 0PE

(1762)

BOX NOs.

Box number replies should be addressed to:

Box No.....
c/o Wireless World
Quadrant House
The Quadrant
Sutton, Surrey, SM2 5AS

BBC MICROCOMPUTER "GENLOCK" BOARD

This card enables the video outputs of the computer to be synchronised to an external video or sync. signal. The board is supplied ready to fit inside the computer. Send s.a.e. to

ABBEY AUDIO, PO BOX 2
STAINES, MIDDX. TW18 2NH

(2289)

ENCAPSULATING EQUIPMENT FOR coils, transformers, components, degassing silicone rubber, resin, epoxy. Lost wax casting for brass, bronze, silver, etc. Impregnating coils, transformers, components. Vacuum equipment, low cost, used and new. Also for CRT regunning metallising. Research & Development. Barratts, Mayo Road, Croydon CR0 2QP. 01-684 9917. (9678)

LAMPS AND CABLE. Large amount of lamps and cable for sale – all types and sizes, domestic and industrial. Telephone MIRAGE LIGHTING on HITCHIN (0462) 733388 between 10am-7pm. (1809)

THE SCIENTIFIC WIRE COMPANY

811 Forest Rd, London, E.17. Tel. 01-531 0574

ENAMELLED COPPER WIRE

SWG	1lb	8oz	4oz	2oz
8 to 34	£3.63	£2.09	£1.10	£0.88
35 to 39	£3.82	£2.31	£1.27	£0.93
40 to 43	£6.00	£3.20	£2.25	£1.61
44 to 47	£8.67	£5.80	£3.49	£2.75
48	£15.96	£9.58	£6.38	£3.69

SILVER PLATED COPPER WIRE

14 to 30	£9.09	£5.20	£2.93	£1.97

TINNED COPPER WIRE

14 to 30	£3.97	£2.41	£1.39	£0.94
Fluxcore Solder	£5.90	£3.25	£1.82	£0.94

Prices include P.&P. and VAT. Orders under £2 add 20p. S.a.e. for list of copper and resistance wire. Dealer enquiries welcome. (9063)

www.americanradiohistory.com

Classified

SITUATIONS VACANT

Supervisor
Professional Audio Service

We are a world leader in the professional broadcast industry with our international headquarters for Europe, the Middle East and Africa located in North Hampshire. Our range of audio equipment includes analogue and digital studio tape recorders, mixing consoles, wireless microphones and digital products.

A person is now required to head a small team involved with the servicing of the full range of our professional audio products.

The ideal candidate will have experience of supervising engineering personnel engaged in the installation, testing and commissioning of sound studio equipment. Knowledge of current digital and analogue techniques as applicable to the audio industry is essential. The person we are seeking will be a 'hands on' member of the audio service team and as such some travel away from home is envisaged.

We offer an excellent benefits package, including attractive salary, Company Car, Pension/Life Assurance Scheme, and free private medical cover. If you are interested please write with details of career to date to Mike Jones, Senior Personnel Officer, Sony Broadcast Limited, City Wall House, Basing View, Basingstoke, Hampshire RG21 2LA.

SONY® Broadcast

Sony Broadcast Ltd.
City Wall House
Basing View, Basingstoke
Hampshire RG21 2LA
United Kingdom

(2244)

UNIVERSITY OF CAMBRIDGE
School of Clinical Medicine

SENIOR ELECTRONICS ENGINEER

The successful candidate will be in charge of a small Electronics Workshop providing design, maintenance and repair of equipment for all departments of the Clinical School.

Applicants should have HNC/HTEC or a Degree in Electronics with several years of experience in both analogue and digital electronics.

Salary on scale £7,232-£8,722. For further information contact Dr R. Hanka at 0223-358217.

Applications naming two referees should be sent by 30 September, 1983, to the Secretary of the Clinical School, Addenbrooke's Hospital, Hills Road, Cambridge CB2 2QQ.

(2252)

ARTICLES FOR SALE

QUARTZ CRYSTALS IN 24 HOURS
ANY FREQUENCY 2-50 MHz FOR £5 inc

New fast service for C.W.O. only (state holder style).
Clock oscillators for microprocessors in stock from £9.30.

McKnight Crystal Co Ltd, Hardley Industrial Estate Hythe, Southampton SO4 6ZY Tel. 0703 848961

(2008)

AUTOMATIC COIL WINDER. Blume and Redecker, £450 also equipment and stock for loudspeaker manufacturing. Cheap for clearance. Details Batley (0924) 470757. (2248)

WAVEGUIDE, Flanges and Dishes. All standard sizes and alloys (new material only) from stock. Special sizes to order. Call Earth Stations, 01-228 7876, 22 Howie Street, London SW11 4AR. (2099)

IBM SELECTRIC (GOLFBALL) I O Terminal with driver electronics. Recently overhauled, cw Golfball 8 and ribbon, ready to go as typewriter. Circuits and some useful bits to enable computer interface to be built; £180. Staines (0784) 52067 (evenings) 2286

VALVES, PROJECTOR Lamps, 6000 types, list 75p, world wide export. Cox Radio (Sussex) Ltd., The Parade, East Wittering, Sussex. Phone (024 366) 2023. (1991)

ARTICLES FOR SALE

TO MANUFACTURERS, WHOLESALERS BULK BUYERS, ETC.
LARGE QUANTITIES OF RADIO, TV AND ELECTRONIC COMPONENTS FOR DISPOSAL

SEMICONDUCTORS, all types, INTEGRATED CIRCUITS, TRANSISTORS, DIODES, RECTIFIERS, THYRISTORS, etc. RESISTORS, C/F, M/F, W/W, etc CAPACITORS, SILVER MICA, POLYSTYRENE, C280, C296, DISC CERAMICS, PLATE CERAMICS, etc.

ELECTROLYTIC CONDENSERS, SPEAKERS, CONNECTING WIRE, CABLES, SCREENED WIRE, SCREWS, NUTS, CHOKES, TRANSFORMERS, etc.

ALL AT KNOCKOUT PRICES – Come and pay us a visit ALADDIN'S CAVE

TELEPHONE: 445 0749/445 2713

BROADFIELDS & MAYCO DISPOSALS
21 Lodge Lane, North Finchley, London, N.12
(5 minutes from Tally Ho Corner) (1613)

RADIO AND TV SERVICING 1982-83 MODELS

by R. N. Wainwright Price £23.50

THE ART OF ELECTRONICS by Horowitz Hill Price £16.00

INTEGRATED ELECTRONICS by Millman-Halkias Price £11.25

PRINCIPLES OF INTERACTIVE COMPUTER GRAPHICS by William M. Newman Price £12.50

BASIC PRINCIPLES AND PRACTICE OF MICROPROCESSORS by D. E. Heffer Price £6.50

VHF UHF MANUAL 4th Ed. by G. R. Jessop Price £10.00

INTERNATIONAL VIDEO YEARBOOK 1983/84 Price £26.00

DOMESTICE VIDEOCASSETTE RECORDERS by Steve Beeching Price £15.00

1983 THE RADIO AMATEUR'S HANDBOOK Price £10.00

TOWERS' INTERNATIONAL MOSPOWER AND OTHER FET SELECTOR by T. D. Towers Price £10.50

★ ALL PRICES INCLUDE POSTAGE ★

THE MODERN BOOK CO.

BRITAIN'S LARGEST STOCKIST of British and American Technical Books

19-21 PRAED STREET LONDON W2 1NP

Phone 01-402 9176

Closed Saturday 1 p.m.
Please allow 14 days for reply or delivery

(2245)

INVERTERS

A new UPS with advantages for computer users:

- ★ More efficient giving a longer supply time from the battery
- ★ Static switch faster and more reliable
- ★ Long term power drain from mains 1/10th of normal
- ★ Frequency and sine wave better controlled
- ★ Mains filtered and delivered even if inverter fails
- ★ Smaller and lighter overall
- ★ 500 VA to 10 KVA
- ★ Complete UPS in a modern cabinet

Interport Mains-Store Ltd
POB 51, London W11 3BZ
Tel 01-727 7042 or 0225 310916

(9101)

EURO CONNECTORS, din 41612, 2 × 32 st pin socket, £2.20; 2 × 32 ang. pin plug, £2.20; 3 × 32 ST pin socket, £2.50; 3 × 32 ang. pin plug, £2 50; 9u high euroracks with divisions, £25; 1/4 wt. piher metal film resistors. Popular values, £4.80 per thousand s.a.e. for list. MJ 3000 Darlington transistors, 90p. 1,000 metres of 25-core, individually screened cable 50 OHM Offers over £500. Photographic and Optical Services Ltd., 129-137 Stanley Road, Teddington, Middx. Tel: 977 3498. 214

RACAL COMMUNICATION RECEIVERS

500Kc s to 30Mc s IN 30 BANDS 1Mc s WIDE **RA17 MK11** – £100 – **RA17L** £150 **RA117E** – £225 NEW METAL LOUVERED CASES FOR ABOVE £25 EACH ALL RECEIVERS ARE AIR TESTED AND CALIBRATED IN OUR WORKSHOP SUPPLIED WITH MANUAL AND DUST COVER IN FAIR USED CONDITION **RACAL SYNTHESISERS** (DECADE FREQUENCY GENERATOR) **MA350B** – SOLID STATE FOR USE WITH MA79 RA117 – RA217 – RA1217 ETC, £100 to £150 – MA250 1.6Mc s TO 31.6Mc/s – £100 to £150 **MA259G PRECISION FREQUENCY STANDARD** – 5Mc/s – 100Khz £100 to £150 **EDDYSTONE RECEIVER TYPE EC964-7K** SOLID STATE SINGLE CHANNEL SSB MAINS OR BATTERY POWERED 1.6 to 27.5Mc/s AND 400 – 535Khz £100 WITH MANUAL **REDIFON SSB RECEIVER TYPE R499** SOLID STATE 10 FIXED CHANNELS RANGE 1.5 TO 30Mc/s AND 255Khz TO 525Khz POWER MAINS OR BATTERY COMPLETE WITH ISB ADAPTOR ARU10A – £100 WITH MANUAL **REDIFON TT10 OR TT11 AUDIO TELEPRINTER CONVERTOR** SOLID STATE – TESTED WITH CIRCUIT £25 **CREED TYPE 75 TELEPRINTER** 50 AND 75 BAUDS FOR USE WITH ABOVE CONVERTOR £25

OSCILLOSCOPES

CT436 DUAL BEAM OSCILLOSCOPES – 6Mc/s £45 **TEKTRONIX 647A** 100Mc/s DUAL TRACE SOLID STATE £350 WITH MANUAL **MARCONI TF995 SIGNAL GENERATORS** FROM 2Mc s OR 1.5Mc s TO 220Mc/s AM FM A2M £80 – A3 £80 – A5 £150 WITH MANUALS **TF2006 DIFFERENTIAL DC VOLT METER** 0 TO 1100 volts – £100 **TF2002 AM SIGNAL GENERATOR** – 10Kc s TO 72Mc/s – £300 **TF2002AS** FM AND AM SIGNAL GENERATOR 10Kc s TO 72Mc/s £600 **TF2170B DIGITAL SYNCHRONIZER** FOR ABOVE £350 **TF1066B/S FM AM SIGNAL GENERATOR** 10Mc s TO 470Mc/s £300 **TF1246 CIRCUIT MAGNIFICATION METER** AND TF1246 OSCILLATOR £200 **H.P SIGNAL GENERATORS** 620B 7 TO 11 GIGS £150 **608** 10 420Mc/s £70 612A 450 1200Mc s £200 **MARCONI AF WATT METER CT44 N01** ABSORPTION 200 MICROWATTS TO 6 WATTS IN 10 RANGES SWITCHED 2150 Ohms £45 **TF893A AF WATT METER** 1 MILLIWATT TO 10 WATTS 2.5 Ohms TO 20K Ohms IN 48 STEPS £65 **THYRISTOR TEST SET CT568** VOLTAGES UP TO 2KV £100 **TEKTRONIX 4002A GRAPHIC COMPUTER TERMINAL WITH JOYSTICK** £400 **TEKTRONIX 4601 HARD COPY UNIT** FOR USE WITH ABOVE £150 BOTH UNITS FOR £500 **RACAL DIGITAL COUNTERS** TYPE 801M 125Mc s £50 **RACAL 836 COUNTER** 35Mc s £50

V A T AND CARRIAGE ON ABOVE ITEMS EXTRA

ALL ITEMS ARE BOUGHT DIRECT FROM H M GOVERNMENT BEING SURPLUS EQUIPMENT PRICE IS EX WORKS S A E FOR ALL ENQUIRIES PHONE FOR APPOINTMENT FOR DEMONSTRATION OF ANY ITEM

JOHN'S RADIO
WHITEHALL WORKS, 84 WHITEHALL ROAD EAST
BIRKENSHAW, BRADFORD BD11 2ER
TEL (0274) 684007

WANTED REDUNDANT TEST EQUIPMENT RECEIVING AND TRANSMITTING EQUIPMENT VALVES PLUGS AND SOCKETS SYNCHROS, ETC (848)

Philips FM/AM/Mark Generator £89, accessory extension generator £59. Marconi 9100-9600 Test Set, £75. FM/AM Modulation meter £85. Fonadek (NO HANDS) telephone adaptors £17, £25. Transformers for up to 14 KVA single to 3-phase converters £65 each, range of accessories available, capacitors, auto-start contactors, switches etc., circuit diagram for transformer purchasers. Line Output Transformer test equipment with digital and analogue meters £75. Centrifuge £49. Pair Sonatest probes £25. Pressure vessels for surface coating £55, spray heads £35. Marconi 'Q' meter £45. Sweep generators. Industrial microscope £98. Brinell Hardness Tester with microscope £175. Wow and Flutter meter £75. Marconi double pulse generator £59. Fluoride test probe £20. Electronic Water temperature probe for thermostat control, pH measurement correction etc., £7.50. Thermocouple probes £5. Electronic Thermocouple Temperature meter, Cr/Al, Fe/Con., Cu/Con, mV, £35. Large Hi-Vac pump with motor on base and drive guard £129, (free with pump: Pyrani Gauge unit, two valves, diffusion pump), Lightweight hydraulic crane, steerable wheels, dismantles for transit (e.g. in car) £89. **040-376236** (2016)

SURPLUS ELECTRONIC COMPONENTS: Transistors, power transistors, triacs, thyristors, meters, integrated circuits, presets. All unused and in new condition. Send s.a.e. for lists or phone Clarian Controls, 29 32 Cumberland Estate, Loughborough, Leics. LE11 0DE. Tel: 0509 230048. 2288

RACAL RA1792 Receiver, 30MHz, synthesized, current production £3,000, £6,000 and new. Approx. 18 months old. 0422 822075 W. Yorks. (evenings). (2253)

SMALL BATCH PCB panel assembly to drawing or sample. Competitive rates, quick turnaround. Delta Engineering, 85 Sewell Highway, Coventry (0203) 449391 443895. (2227)

WANTED: Spectrum Analyser, £1,000. 01-556 3734. (2254)

www.americanradiohistory.com

COURSES

New Course in Telecommunications

A new three year BSc(Eng) Degree course is being launched in September 1984 by the Department of Electrical and Electronic Engineering at Queen Mary College.

This course covers all important aspects of commmunications from microwave and optical systems to the design and use of large scale communication networks. It provides a firm foundation for a student wishing to enter any part of the telecommunications industrty.

Further information from: Dr E. M. Scharf
Department of Electrical and Electronic Engineering
Queen Mary College, University of London
Mile End Road, London E1 4NS

(2249)

CAPACITY AVAILABLE

P.C.B's

Printed Circuit Boards to your specification from artwork through to finished board.

QUICK DELIVERY – COMPETITIVE PRICES

CROFTON ELECTRONICS LIMITED
35 Grosvenor Road,
Twickenham, Middlesex
TEL 01 891 1923/1513 Telex 295093

BATCH PRODUCTION wiring and assembly to sample or drawings. McDeane Electricals Ltd, 19b Station Parade, Ealing Common, London W5. Tel: 01-992 8976. (169

FREE PROTOTYPE of the finest quality with EVERY P.C.B. artwork designed by us. Competitive hourly rates, and high standard of work. Halstead Designs Limited. Tel: Halstead (0787) 47740B. (2126)

TW ELECTRONICS LTD
THE PCB ASSEMBLERS

More and more companies are investigating the advantages of using a professional subcontractor. Such an undertaking requires certain assurances.

TW are able to satisfy all of them – quality, competitive pricing, firm delivey and close co-operation with the customer.

Assembled boards at 100% inspected before flow soldering and reinspected after automatic cropping and cleaning.

Every batch of completed boards is issued with a signed certificate of conformity and quality – our final assurance.

For further details, contact us at our new works:

Blenheim Industrial Park
Bury St. Edmunds
Suffolk IP33 3UT
Telephone: 0284 3931 (1466)

PCB/ELECTRONIC ASSEMBLY

- ★ Circuit Design & Development
- ★ Prototyping
- ★ Pre-production Consultancy
- ★ Full Production Capability
- ★ Component Sourcing & Stocking
- ★ Complete Test Facilities

STAGECRAFT (ELECTRONICS) LTD
3 Churchfield Road
Acton Central, W3 6BH
Tel: 01-993 1852/3660
(2203)

BUSINESS OPPORTUNITIES

FOR SALE: Well-established radio communications business serving Devon and Cornwall. Rentals, sales, servicing. Excellent connections and growth potential. Please contact Page, Homeleigh House, East Taphouse, Liskeard, Cornwall. Phone: 0579 20187. (2287)

Box number replies should be addressed to:

Box No.....
c/o Wireless World
Quadrant House
The Quadrant
Sutton, Surrey, SM2 5AS

ARTICLES FOR SALE

THERMIONIC VALVES

Various types available. Details from G. E. Moss. Telephone 01-248 1202, ext. 2802. Closing date for receipt of enquiries: October 1, 1983.

Trade enquiries only

(2250)

EX WD Radio equipment and test equipment. Over 500 sets in stock from £8. Send 50p for illustrated catalogue (including £1 voucher). Weirmead Ltd. 129 St. Albans Road, Watford, Herts. Tel: Watford (0923) 49456. (1974)

BRIDGES, waveform/transistor analysers. Calibrators, Standards. Millivoltmeters. Dynamometers. KW meters. Oscilloscopes. Recorders. Signal generators – sweep, low distortion, true RMS, audio, FM, deviation. Tel. 040 376236.

PHONE YOUR CLASSIFIEDS TO IAN FAUX ON 01-661 3033

SERVICES

CIRCOLEC
THE COMPLETE ELECTRONIC SERVICE

Artwork, Circuit Design, PCB Assembly, Test & Repair Service, Q.A. Consultancy, Prototypes, Final Assembly. Full PCB Flow Soldering Service.

Quality workmanship by professionals at economic prices.

Please telephone **01-646 5686** for advice or further details.

TAMWORTH MANOR
302-310 COMMONSIDE EAST, MITCHAM
(1391)

FOR THE BEST PCB SERVICE AVAILABLE

★ **Circuit Design & Development**
Digital and Analogue

★ **Artwork Layout**
Work of the highest standard by experienced draughtsmen. No minimum charge.

★ **Board Manufacture**
Prototype to semi-production, excellent rates, 24-hour prototype service from filmwork.

★ **Wiring & Assembly**
PCB assembly, wiring and cable forming by qualified staff.

★ **Test**
Full test facilities available.

One or all services available, no order too small. Please telephone Chelmsford (0245) 357935, or write to HCR Electronics, The Industrial Unit, Parker Road, Chelmsford. (1169)

REPAIRS & SERVICE

- ★ COMPUTERS (BUSINESS AND PERSONAL)
- ★ DISC DRIVES (5¼" × 8")
- ★ VDUs
- ★ PRINTERS
- ★ S100 BOARDS
- ★ EPROM PROGRAMMING
- ★ MAINTENANCE CONTRACTS

48 hour service for alignment and test of disc drives.

A. N. ELECTRONIC & COMPUTER SERVICES LTD
130B North Lane, Aldershot, Hants
Tel: Aldershot (0252) 25608
(2247)

Williams
P.C.B. Artworks FAST TURNROUND

Cost effective specialist layout and master artwork
WILLIAMS ARTWORK
GRAYS LANE, MORETON-IN-MARSH, GLOS.
Telephone 0386 832152 – to 9 p.m.
(1971)

MENDASCOPE LTD

Repair and recalibrate oscilloscopes

All makes – all models

MENDASCOPE LTD
Otter House, Weston Underwood
Olney MK46 5JS
Tel: Bedford (0234) 712445
(2230)

EPROM PROGRAMMING

From list and/or existing EPROM for most 5v N.MOS types. Charge £2.50 + 12 pence per 32 words manually entered. Erasing and EPROMS also available.

Bandley Chipware
28 Boroughgate
Appleby
Cumbria CA16 6AG
Tel: 0930 51027
(2202)

ELECTRONIC (ANALOG AND DIGITAL), ELECTRO PNEUMATIC AND CONTROL SYSTEMS R & D. Facilities for long or short run assembly and test to your design or ours at our new Maidstone facility.

48 SOUTHWARK STREET
LONDON SE1 1ON
Telephone: 01-407 7441
Telex: 8954665 GITS SER (2281)

DESIGN AND DEVELOPMENT. ANALOGUE, DIGITAL, RF AND MICROWAVE CIRCUIT AND SYSTEM DESIGN. Also PCB design, mechanical design and prototype/small batch production. – **Adenmore Limited,** 27 Longshot Estate, Bracknell, Berks. Tel: Bracknell (0344) 52023. (656)

TURN YOUR SURPLUS Capacitors, transistors, etc, into cash. Contact COLES-HARDING & Co., 103 South Brink, Wisbech, Cambs. 0945-4188. Immediate settlement. We also welcome the opportunity to quote for complete factory clearance. (9509.

SMALL BATCH PCBs, produced from your artwork. also DIALS, PANELS, LABELS. Camera work undertaken. FAST TURNAROUND. Details: Winston Promotions, 9 Hatton Place, London EC1N 8RU. Tel. 01-405 4127/0960. (9797)

Analogue integrated circuit design on a single chip. Phone Four-D Limited on 0279-29246. 2159

PCBS & PANEL LABELS to your requirements. Design – Prototypes – Production. G. N. Slee Custom Products, 78 Derry Grove, Thurnscoe, Rotherham, Yorks SG3 0TP. Telephone (0709) 89525. (1892)

DESIGN SERVICES. Electronic design development and production service available for digital and analogue instruments. RF Transmitters and receivers, telemetery and control systems. 20 years' experience. R.C.S. Electronics, Wolsey Road, Ashford, Middlesex. Phone Mr Falkner 53661. (8341

ARTICLES WANTED

SURPLUS

Top prices paid for surplus, redundant and obsolete test equipment, factories cleared.
Also quantities of components.
Immediate settlement. We will call anywhere in the United Kingdom.

TIMEBASE
94 Alfriston Gardens
Sholling, Southampton SO2 8FU
Telephone: (0703) 431 323
(1852)

ANTIQUE RECEIVING VALVES

Unused and boxed
In large quantity

Tsutom Yoshihara
C1-105, Deguchi-cho 34
Suita-shi, Osaka 564
JAPAN
(2055)

WANTED

Test equipment, receivers, valves, transmitters, components, cable and electronic scrap, and quantity. Prompt service and cash. Member of A.R.R.A.

M & B RADIO
86 Bishopsgate Street
Leeds LS1 4BB
0532 35649

www.americanradiohistory.com

COMPUTER APPRECIATION

86 High Street, Bletchingley, Redhill, Surrey RH1 4PA – Tel: Godstone (0883) 483221

DATA GENERAL Micro Nova System comprising MP/200 processor with 64KB memory, Model 6096 1.26MB diskette, Model 6101, 12.5MB Winchester disc drive, 4-line synchronous/asynchronous multiplexor, Model D200/100 VDU and Model LP2 (6190) line printer. With RDOS Operating system including business basic. Manufactured 1982 ..... **£3900**
RAIR Model 320 BLACK BOX Microcomputer System with twin 5¼in. floppy disc drives, 128KB memory, 10MB 8in. Winchester disc drive, 8-line terminal multiplexor **£2250**
PDP 11/03 SYSTEM comprising LSI 11/2 processor with EIS/FIS, 64KB memory, PERTEC 20MB front-loading disc drive (RK-05 compatible), DILOG Model DQ100 disc drive controller, DLV11, LPV11, LEAR SIEGLER Model 200 180 cps bidirectional printer, HAZELTINE Model 1552 VDU with PROMS for VT52 compatibility. With RT-11 operating system **£2900**
TEXAS INSTRUMENTS Model 771 Microcomputer System with VDU screen and keyboard with integral thermal printer (Silent 700 type) and Model FD800 dual 8in. floppy disc drives. Based on TMS9900 16-bit processor and with 64KB memory **£650**
INTEGRATED COMPUTER SYSTEMS 8080 TRAINER. Suitcase-mounted training system with HEX keyboard and a variety of I/O (incl. motor, speaker, thermistor). Currently around £1,000 new **£95**
ADDS Model Regent 60 intelligent VDU, 24 × 80, 9600 Baud **£250**
NEWBURY DATA Model 24 × 80 VDU, RS232 up to 9600B. Upper case characters only **£95**
DATAMEDIA VDU, 24 × 80, with upper/lower case, RS232 up to 9600B, detached keyboard with numeric keypad and cursor control keys, graphics character set **£150**
HONEYWELL Model L1000 printing terminal, 300B with self-test, etc., new **£150**
DATA DYNAMICS Model ASR 390 TELETYPE, 110B printing terminal with paper-tape reader and punch **£150**

FACIT Model 4020 Paper-Tape Reader, 300cps, TTL parallel interface, companion to model 4070 punch **£185**
DEC Paper Tape Reader/Punch (300cps/75cps) **£125**
EXTEL Baudot Coded Matrix printer **£150**
EXTEL Terminal as above, 50 and 75B with keyboard. Adaptable for TELEX use **£195**
MANNESMAN/TALLY Model M80MC/77 Matrix Printers. Featuring: Microprocessor control, 200cps bidirectional printing, u/l case, self-test, all electronics on single board, heavy-duty mechanism for serious commercial use. We have 20+ of these machines in stock for 110V operation, all of which are BRAND NEW and boxed ..... **P.O.A.**
MANNESMAN Model M78 Matrix Printer **£100**
General Electric Model 300 Terminet Printing Terminal. With keyboard and correspondence quality printer **£150**
HEWLETT PACKARD Model 7905A front-loading 15MB disc drive for 3000 Series computers. Trolley mounted **£650**
CDC Model 9414 FALCON 10MB Disc Drive. With the same interface as the CDC Hawk **£50**
DEI Model 3637 Magnetic Tape Cartridge Drive (streamer type). 1600bpi, capacity up to 10MB per cartridge. Interfaceable to most micros **£75**
CDC Model 9400 single-sided, single or double density 8in. Floppy Disc Drives in rack mounting box with 24V power supply. PER PAIR **£100**
CDC Model 9400 double sided, double density 8in. Floppy Disc Drive, as new **£100**
DEC NCV11 GAMMA CAMERA CONTROL for PDP11 Q-Bus. On two quad boards **£650**
DEC BA11MF 8-slot box, backplane and power supply for Q-bus **£500**

Please Note: ★ VAT and carriage extra on all items ★ All visitors by telephone appointment, please ★ We are keen to buy all good secondhand and surplus equipment

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 101-111

PAGE

Aero Electronics (AEL) Ltd 50
Ambit International 49
Anders Electronics Ltd 17
Antex (Electronics) Ltd ..... Cover iii
Armon Electronics Ltd 92
Aspen Electronics Ltd 83
Audio Electronics 19

Bamber, B. Electronics 100
Binary Systems 94
Black Star Ltd 100
Bread Board '83 96
Broadfields & Mavco Disposals 50

Carston Electronics ..... Loose Insert
Clark Masts Ltd 17
Clef Products (Electronics) Ltd 92
Colomor (Electronics) Ltd 89
Computer Appreciation 112
Control Universal Ltd 85
Cricklewood Electronics Ltd 16

Display Electronics 99
Dwight Cavendish 94

Easibind 100
Electrical Review Shock Cards 100
Electronic Brokers Ltd 3, 5, 7
Electronic Equipment Co. 86
Electroustic Ltd 4
Electrovalue Ltd 3
Essex Electronics Centre 12

Farnell Instruments Ltd 2
Ferranti Electronics ..... Cover iv
Fieldtech Heathrow Ltd 49, 83
Flight Electronics Ltd 11
Future Film Development 17

PAGE

Global Specialities Corporation (UK) Ltd 13
Greatech Electronics Ltd 92
Griftronic Emmission Ltd 9
GP Industrial Electronics Ltd 14, 15

Hameg 8
Happy Memories 89
Harris Electronics (London) 9
Harrison Bros. 5
Hart Electronic Kits Ltd 93
Hilomast Ltd 12
House of Instruments 89
HW International ..... Cover ii

ILP Electronics Ltd 20, 21
Integrex Ltd 8
Irvine Business Systems 18

Klippon Electronics 92

Langrex Supplies Ltd 6
Levell Electronics Ltd 96

Manners, K. T. Design Ltd 83
Marconi Communications Systems 50
Midwich Computer Co. Ltd 9
Monolith Electronics Co. Ltd 13

Northern Computer Fair 84

Olson Electronics Ltd 2
Opus Supplies 22
Orion Scientific Ltd 100

PAGE

Pantechnic 3
PM Components 94, 95
Practical Wireless 18
P & R Computer Shop 4

Radford Audio Ltd 4
Radio Component Specialists 87
Radiocode Clocks Ltd 85
Ralfe, P. F. Electronics 10
Royal Air Force Association 86
RST Valves 6

Sarel Electric Ltd 97
Scenic Sounds Equipment Ltd 86
Scopex Instruments Ltd 97
Skyleader 9
South Midlands Communications Ltd 7
Sowter, E. A. Ltd 50
Special Products (Distributors) Ltd 10
Stewart of Reading 7
Surrey Electronics Ltd 92

Technomatic Ltd 90, 91
Thandar Electronics Ltd 93
Thanet Electronics Ltd 10
Thurlby Electronics Ltd 83
Timebase Ltd 5
T.O. Supplies (Export) Ltd 4

Warwick Design Group 83
Wireless World Circards 88

OVERSEAS ADVERTISEMENT AGENTS

France & Belgium: Norbert Hellin, 50 Rue de Chemin Veat, F-9100, Boulogne, Paris.

Hungary: Ms Edit, Bajusz, Hungexpo Advertising Agency, Budapest XIV, Varosliget.
Telephone: 225 008 – Telex: Budapest 22-4525 INTFOIRE

Italy: Sig C. Epis, Etas-Kompass, S.p.a. – Servizio Estero, Via Mantegna 6, 20154 Milan.
Telephone: 347051 – Telex: 37342 Kompass.

Japan: Mr. Inatsuki, Trade Media – IBPA (Japan), B.212. Azabu Heights, 1-5-10 Roppongi, Minato-ku, Tokyo 106. Telephone: (03) 585 0581.

United States of America: Ray Barnes, Business Press International Ltd, 205 East 42nd Street, *New York*, NY 10017 – Telephone (212) 867-2080 – Telex: 238327.
Jack Farley Jnr., The Farley Co., Suite 1584, 35 East Walker Drive, *Chicago*, Illionois 60601 – Telephone (312) 63074.
Victor A. Jauch, Elmatex International, P.O. Box 34607, *Los Angeles*, Calif. 90034, USA – Telephone (213) 821-8581 – Telex: 18-1059.
Jack Mantel, The Farley Co., Suite 650, Ranna Building, *Cleveland*, Ohio 4415 – Telephone (216) 621 1919.
Ray Rickles, Ray Rickles & Co., P.O. Box 2028, *Miami Beach*, Florida 33140 – Telephone (305) 532 7301.
Tim Parks, Ray Rickles & Co., 3116 Maple Drive N.E., *Atlanta*, Georgia 30305. Telephone (404) 237 7432.
Mike Loughlin Business Press International, 15055, Memorial Ste 119, *Houston*, Texas 77079 – Telephone (713) 783 8673.

Canada: Colin H. MacCulloch, International Advertising Consultants Ltd., 915 Carlton Tower, 2 Carlton Street, Toronto 2 – Telephone (416) 364 2269.
* Also subscription agents.

Printed in Great Britain by QB Ltd, Sheepen Place, Colchester, for the proprietors, Business Press International Ltd, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

© Business Press International Ltd 1983.
Wireless World can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Services Ltd; Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd; William Dawson & Son (SA) Ltd. UNITED STATES: Eastern News Distribution Inc., 14th Floor, 111 Eighth Avenue, New York, NY 10011.

www.americanradiohistory.com

THE NEW ANTEX TCSU-D

At last-a digital soldering unit for £67·50

THE NEW ANTEX TCSU-D gives you total control over production soldering temperatures

Again Antex research and development pays off — with this new high-value high-performance unit. It's simple design incorporates an LED display and a unique ULA integrated circuit, specially designed and produced for Antex by Ferranti. Tight temperature control can be maintained by setting the station — then removing the knob, preventing any further alteration.

For laboratory, for workshop, for production-line — TCSU-D is the station.

Let it figure in your soldering specifications.

- Temperature range — ambient to 495°C.
- Working temperature reached in under 1 minute.
- Detachable sponge-tray — no drips or spillage.
- Includes the world-famous Antex iron.
- Bit temperature maintained to ±5°C.
- Conforms to BS 3456 and CEE 11.
- Zero crossing switching.

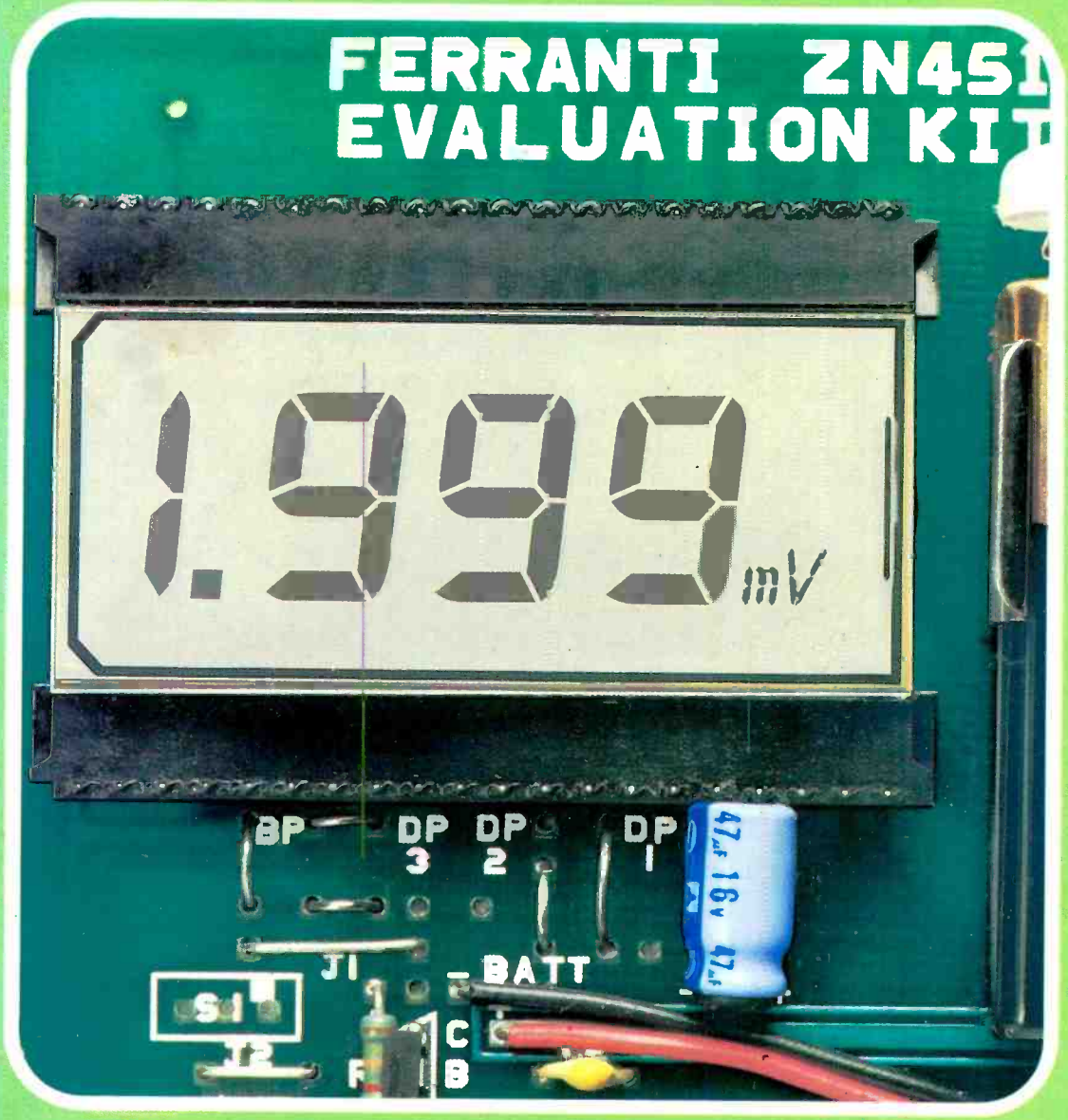
Look into the future of soldering technology - send for the TCSU-D fact-pack now.

ANTEX

ANTEX (Electronics) Ltd.,
Mayflower House, Plymouth, Devon. Telephone: 0752 667377 Telex: 45296

WW-002 FOR FURTHER DETAILS

www.americanradiohistory.com



Better by design

If you're the sensitive type, check out the new ZN451 DVM.

Measuring microvolt signal levels is easy with the new ZN451 DVM IC. It's the first DVM that auto-zeroes external signal conditioning circuits to give full-scale readings as low as ± 1.999 mV with no zero adjustment.

Two logic outputs are provided to control external analogue switches, allowing op-amps and other circuits to be put inside the auto-zero loop and have their offsets cancelled by the ZN451's digital auto-zero system.

Use the ZN451 with pressure transducers, thermocouples, strain gauges or any low output transducer.

To make it even easier there's the ZN451 Evaluation Kit, which contains everything* you need to make a 2mV DVM, available from your Ferranti distributor price £29.50 inc. VAT.

Distributors:
Celdis, Reading, Tel: 0734 585171
Farnell Electronic Comps., Leeds, Tel: 0532-636311
Intel Electronics, Henlow, Tel: 0462 812505
STC Electronic Services, Harlow, Tel: 0279 26777
Midwich Computer Co., Bickinghall, Tel: 0379 898751
Semicomps, Keighley, Tel: 0535 65191
Semicomps, Kelso, Tel: 0573 24366
Swift-Sasco, Crawley, Tel: 0293 28700

Ferranti Electronics Limited,
Fields New Road, Chadderton,
Oldham OL9 8NP. England.
Tel: 061-624 0515 and 061-624 6661
Telex: 668038

FERRANTI
Semiconductors

*Batteries not included

WW–003 FOR FURTHER DETAILS

www.americanradiohistory.com